

**DEVELOPING SITUATIONAL
UNDERSTANDING: WILL A DIGITIZED
FORCE SEE THE 21ST CENTURY FOREST
THROUGH THE TREES?**

**A MONOGRAPH
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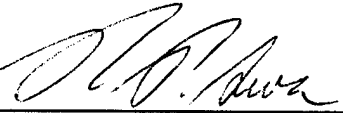
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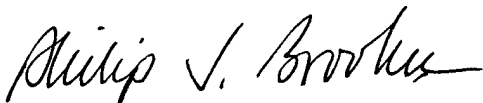
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ABSTRACT

Developing Situational Understanding: Will a Digitized Force See the 21st Century Forest Through the Trees? By MAJ Chester F. Dymek, III, USA, 92 pages.

This monograph answers the question, "Will users of the information technology systems develop the situational understanding and visualization to enhance the battlefield decision making capabilities in the Force XXI mechanized battalions and brigades?" This study first addresses the body of knowledge concerning both the rational and intuitive skills and abilities necessary to make a decision. A central point to the argument is that decision making skills improve with experience and practice from the novice to the expert level. The overall intent is to specifically address expert decision-making strategies in complex, uncertain environments because all military decisions are made in the realm of the uncertain. As noted by our senior leadership, the twenty-first century spectrum of conflict or action will be inherently ill-defined, not because of poor guidance or instruction, but because of the complexity of the problems.

The theory of decision making is uniquely interdisciplinary; the fields of economics, statistics, mathematics, philosophy, operations research, and psychology all permeate the body of research. Decision making theory by itself may also be seen as a theory of best action, not always of rational action. The study also examines human indecision, computer aided decision making, and the development of artificial intelligence. Therefore, the answer to this problem is one that must be multi-modal in its study, design and application.

The context for this question focuses on the current doctrine of battle command and decision making theory. The Great Captains, from Alexander to Napoleon, dominated their battlefields through their tactical genius, expert decision making, and good fortunes. But history is also replete with examples of military failures and misfortunes that were the result of incompetent or novice leadership. The digitization of command, control, communications and intelligence systems enhances the achievement of situational awareness, battlefield visualization, and battle command, but cannot replace the human element. Therefore this is not an assessment of the technical capabilities of the Force XXI material initiatives, but rather an examination of those responsible for making decisions.

Our nation expects and our soldiers deserve expert decision making from their military leadership. This monograph recommends a new way of conceptualizing the battlefield, a different approach of instructing in the school houses, and a fundamental change in the process of developing subordinate leadership skills. The challenge is to develop a new mindset to fully harness the technological advantages of the information age.

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List of Abbreviations

| | |
|---------|---|
| AAN | Army After Next |
| ABCS | Army Battle Command System |
| AFATDS | Advanced Field Artillery Tactical Data System |
| ASAS | All Source Analysis System |
| ASMP | Army Strategic Mobility Program |
| AWE | Advanced Warfighting Experiment |
| BCTP | Battle Command Training Program |
| C2 | Command and Control |
| C3 | Command, Control, and Communications |
| C4 | Command, Control, Communication, and Computers |
| C4I | Command, Control, Communication, Computers, and Intelligence |
| C4I2 | Command, Control, Communication, Computers, Intelligence, and Interoperability |
| C4ISR | Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance |
| CCIR | Commander's Critical Information Requirements |
| CDMP | Combat Decision Making Process |
| CGSC | Command and General Staff College |
| CGSOC | Command and General Staff Officers Course |
| COE | Common Operating Environment |
| CTC | Combat Training Center |
| DAWE | Division Advanced Warfighting Experiment |
| FAADC2I | Forward Area Air Defense Command, Control and Intelligence |
| FBCB2 | Force XXI Battle Command Brigade and Battalion |
| FM | Field Manual |
| GCCS-A | Global Command and Control System - Army |
| IT | Information Technology |
| IVIS | Intervehicular Information System |
| J-STARS | Joint Surveillance Target Attack Radar System |
| MCS | Maneuver Control System |
| MDMP | Military Decision Making Process |
| MIT | Massachusetts Institute of Technology |
| NTC | National Training Center |
| RCP | Relevant Common Picture |
| RMA | Revolution in Military Affairs |
| RSTA | Reconnaissance, Surveillance, Target Acquisition |
| TDMP | Tactical Decision Making Process |
| TFAWE | Task Force Advanced Warfighting Experiment |
| TRADOC | Training and Doctrine Command |
| UAV | Tactical Unmanned Aerial Vehicle |
| USCGSC | United States Army Command and General Staff College |

Chapter I. Introduction

Problem Statement and Research Question. The United States Army is changing from a forward deployed, industrial age force, designed to stop the Soviet Red Army's westward attack through northern and central Europe, to a power projection information age army. Although future focused with the Advanced Warfighting Experiment (AWE), Force XXI Initiatives, and the Army After Next (AAN), today's Army still must prepare to defeat a conventional, adaptive, thinking, industrial era foe. We can expect that the Army "will remain fully engaged throughout the world, meeting the nation's security needs and helping shape the future strategic environment."¹ Our military leadership looks toward technological advances to enhance mobility, survivability and lethality, in order to identify, engage and destroy hostile forces successfully in an unstable, uncertain world.

Through digitization, information age technologies have increased greatly the acquisition and dissemination of data in a rapidly changing military environment.² "Paradoxically, a flood of real or near-real time information places greater demands on intelligence gatherers and decision makers alike, forcing them to rely more on their intuition and Clausewitzian *coup d'oeil* than ever before."³ No matter the amount of information acquired or analyzed, the challenge remains for the decision maker to synthesize quickly and act; this is the intended focus for this paper.

This monograph seeks to answer the question: Can users of the information technology systems develop the situational understanding and visualization to enhance battlefield decision making capabilities in Force XXI mechanized battalions and brigades? This study uses three subordinate questions to argue the research question from the specific to the general. First, what is the individual thought process and how is it developed? Second, what is expert decision making and how does it apply to the military? Finally, what are the requisite abilities decision makers need to achieve battle command in Force XXI?

Technology has not and most likely will not sanitize warfare through automating decisions and (hypothetically) eliminating human error. Technology alone has never been and still is no substitute for effective strategy or tactical execution. This thought will run through a discussion of developmental and decision making theory, expert systems analysis, and automated decision making. This paper centers on the abilities of human beings and not digital devices to make decisions. Ultimately, the conclusion of this

work defines the future requirements for military decision making within the context of battle command in Force XXI.

United States Army Doctrine and Concepts. In order to determine an organization's purpose, direction, and philosophy one may look at the stated practices and beliefs of an institution. The US Army has many published doctrinal documents and developmental concepts that describe how and why it operates or desires to operate in the future. Through these written documents, one may determine how the Army, as an institution, believes military decisions should be made and how decision making skills should be developed. The essential elements for military decision making appear to be the exercise of battle command, the attainment of battlefield visualization, and development of situational awareness. FM 100-5, *Operations* and TRADOC PAM 525-5, the Army's concept for Force XXI operations, define **battle command** as "the art of decision making, leading, and motivating soldiers and their organizations into action to accomplish missions. Battle command includes visualizing the current state and future state, then formulating concepts of operations to get from one to another at the least cost."⁴ The concept of battle command should not focus one on information, but rather knowledge and action.

Thinking and acting are simultaneous activities for leaders in battle, through which the commander interprets the situation and makes a decision. Visualizing the battlefield is a continuing requirement for commanders. **Battlefield visualization** is a component of battle command. It is made possible by the combination of technologically supported information acquisition systems along with the commander's intuition, judgment, wisdom, and experience. It consists of the ability of the commander to form a mental picture of the current and future state based on a higher commander's intent, available information, and intuition.⁵ Battlefield visualization is related, but not identical to situational awareness.

FM 100-5, *Operations* defines **situational awareness** as "the knowledge of physical forces on the battlefield in relation to the nature, scope, and tempo of the operation. It includes the ability to identify patterns and relationships, to understand the critical points in time and space, and to recognize opportunities for decisive action." Leaders "must assimilate thousands of bits of information to visualize the battlefield, assess the situation, and direct the military action required to achieve victory [emphasis

added].”⁶ The underlined portions of the previous definitions are the focus of this paper’s initial research: the mental activity of thought is a complex process of the highest order.

The Army’s doctrine of battle command, battlefield visualization, and situational awareness describe a future state of military decision making that Force XXI units should possess. The doctrine describes the future state, but does not indicate how one develops the requisite skills to harness the advantages of information technology systems and assist in the decision making process. This monograph focuses on defining the human requirements to develop military decision making as envisioned in Force XXI.

Recent U.S. Army Training Experiences. Recent U.S. Army training experiences demonstrate that although one of the tremendous advantages to digitization is increased speed of data flow, the quality of decisions has not improved in terms of agility and depth of thought. Our smaller, more lethal and more agile Army of the future requires leaders to harness information technologies and increase their decision making speed, as well as improve their completeness of thought and creativity in determining solutions.

The task force and division Army Warfighting Experiments (TFAWE and DAWE) indicated that digital technologies significantly enhanced unit capabilities, but units were not confident in the reliability of all the systems. Commanders and staff officers at the Task Force AWE (TFAWE) either failed to trust the information available, or desired more before deciding, thereby forfeiting the potential initiative to the enemy.⁷ However, the decision making process for the senior officers (Colonel and above) improved during the Division AWE (DAWE), presumably because of their experience in making decisions with far less timely or accurate information. It was not because of improved staff actions or a more effective implementation of the technologies.⁸ The common assumption is that a hesitation in decision making is based on a desire for more certainty; knowledge of enemy and friendly units. Certainty in this context is not completeness of thought, but rather accumulation of more data. The junior commanders and staff officers who lack experience and knowledge to make rapid decisions appear to be hampered by the information presentation in its current format.⁹ It remains a difficult task to substitute technology for experience, practice and study, in order to develop battlefield intuition.

This deficiency in decision making skills or abilities is not unique to the units involved with the AWE and it is not a technical problem. The Battle Command Battle Lab report, *Focused Rotation Findings*, describes the baseline assumption that, if a leader can answer the basic questions of friendly and enemy unit location and activity, then he or she can make a decision.¹⁰ That information is only part of the solution. One must understand the relationships between all the parts of the problem one is confronting and then have the ability and will to decide. The typical difficulties noted during the Combat Training Center (CTC) and the Battle Command Training Program (BCTP) exercises include:

1. Commander's failing to assimilate doctrine into their decision making;
2. Commander's failing to understand the military decision making process;
3. And commander's failing to synchronize the assets available.¹¹

The performance of junior field grade officers involved in **Prairie Warrior 1998**, and the June 1997 DAWE National Training Center (NTC) rotation, indicates that increasing the amount of data supplied to the decision maker is an inferior substitute for experience. Computer generated graphics, the data of the Maneuver Control System (MCS), and the All-Source Analysis System (ASAS), provided data faster, but unfiltered and more uninterpreted data did not improve the quality or timeliness of the decision made. Some staff officers could develop a sense of terrain appreciation through three dimensional modeling and memorization, but not in terms of the effects on the forces. For example, one needs to understand such facts as that the fourth sixty-ton tracked vehicle moving over a snow covered trail creates ice through compression, or that the water which gathers in small seasonal inlets damages the guidance wires attached to some anti-tank missiles, in order to make use of raw terrain detail on expected unit operations.¹²

Recent U.S. Army training experiences demonstrate that decision making has not improved significantly with the implementation of information technologies. Commanders and staffs at the lower levels of the Army organization continue to experience difficulties in mastering the art of battle command, battlefield visualization, and situational awareness. They lack the apparent requisite skills to harness the advantages of information technology systems and assist in the decision making process.

Leaders may not only lack certain technical skills, but may also fail to comprehend the intentions of doctrine. Confusion develops within an organization when the stated doctrine or concept varies from

what is in use by the institution. For example, the term "Relevant Common Picture" (RCP) describes a uniform presentation of the desired information. The RCP as a digital, near-real time representation of the location of friendly and enemy units, is a means to situational awareness, not the end.¹³ However, there may be a misperception within the Army that viewing the relevant common picture is achieving situational awareness, rather than an element of situational awareness.¹⁴ The communicated thought is that gaining situational awareness is merely being aware of the enemy and friendly units, rather than the totality of a thought process and action as stated in the Army's doctrinal publications. One military publication about the employment and capabilities of information technologies defines situational awareness as "the ability to have accurate and real-time information of friendly, enemy, neutral, and noncombatant locations; a common, relevant picture of the battlefield scaled to specific level of interest and special needs."¹⁵ As we develop the terminology and record the lexicon of Force XXI and the Army After Next, we should appreciate how the force receives the message may be more pertinent than how the message is presented.

So then, what is important about the notion of Relevant Common Picture to the research question? Understanding an RCP is pertinent to discussing the ability to achieve situational awareness and battlefield visualization within the decision making process. The organization and presentation of data in the RCP improves the decision maker's information processing capability. The RCP does not mean the digital system presents the same picture to each person, rather each decision maker has a view of the battlefield with the appropriate level of detail based on a common database. As the quality of information, not quantity of facts, improves during mission analysis through execution, leaders will be able to manage forces more effectively and focus on the enemy. This data may translate into horizontally and vertically shared information, but raw data alone should not be used interchangeably with thought process that develops situational awareness. Given the Army's doctrine, concepts, and recent experiences, what methodology then could answer the primary and subordinate research questions?

Methodology. The objective of this monograph is not to validate or assess the effectiveness of the digitization of information systems. Whether or not the systems can produce more and improved information faster is not the question. Army doctrine that is vague or misleading may be clarified through

further explanation or redefinition of the terms, followed by promulgation of the desired meaning to the entire force structure. This monograph answers the challenges posed by the recent U.S. Army training experiences with regard to a thought process that facilitates decision making and mastering the art of battle command, battlefield visualization, and situational awareness. The methodology of this paper is to define the individual thought process and its development. Given a theoretical discussion on the development of a thought process, the next step is to recognize expert decision making and its application in the military. This paper then identifies the requisite abilities decision makers need to achieve battle command, battlefield visualization, and situational awareness in Force XXI warfare, and proposes a course of implementation for the Army's training and education programs.

The limitations of the research involve assessing and attributing decision results to the commander's experience and wisdom alone. Outcome measurements (placing relative values for success or failure of the mission) depend on many extraneous variables, making it difficult to isolate the dependent variables of the decision. Superior execution could overcome the shortcomings of an inferior decision. There are so many differences between even the same individual performing as a battalion commander and then as a division commander that it is infeasible to quantify or qualify a response scale. The value of the past experiences of any decision maker would be very difficult, if not impossible, to measure.

Given the theoretical challenges of analyzing the decision making process, versus analyzing a decision, one must first develop a framework to identify the cognitive thought processes within decision making before applying measurement criteria to a decision. Some of the key elements in the cognitive process of decision theory include: patterns, perceptions, predictions, linkages, assumptions, possibilities, and confidence. For the purposes of this discussion one could group the subjects of patterns, perceptions, and predictions under the general heading of mental models. Another category for discussion in this monograph would include linkages, assumptions, possibilities, and confidence under the topic of expert-decision making. The importance here is not on how well individuals perform, but how they perform. This paper does not evaluate the analytical decision making process of the MDMP, but focuses on the development and use of mental models and decision making abilities of the individual commander.

For the purpose of this monograph the evaluation criteria should apply to general decision making theory, military decision making strategies, and computerized decision making processes. The evaluation criteria for analyzing the development of the individual decision making process will be depth, versatility, agility, and the "Law of Diminishing Returns."

1. **Depth.** Depth of thought and decision making is not measured in terms of spatial battlefield relationships, but of completeness of thought. The ability to predict second and third order consequences and possibilities; thinking to achieve future results. Depth of thought is seeing the linkages between objects and events, anticipating and making assumptions.

2. **Versatility.** Versatility of thought is the ability to discover unique, creative solutions to routine and ill-defined problems. There are many different ways to solve problems, and versatility of thought has always been akin to initiative in the US Army. The diverse requirements of a power projection force in the 21st century demand versatile thought. There is no stated or perceived desire to create a computer-based solution set thereby limiting creativity and versatility of thought.

3. **Agility.** Agility is the mental acuity to solve complex problems quickly in order to control the tempo through actions that seize the initiative. There are many models and paradigms that attempt to explain the thought process and expert decision making. Colonel John Boyd, a retired Air Force fighter pilot, studied the performance of successful aviators in air to air combat. His theory called the OODA loop (Observe-Orient-Decide-Act, see Annex B, Decision Making Models, Figure 1) is the central theme to the theory of maneuver warfare, act faster than the enemy until he no longer has the ability to fight.¹⁶ In the data overload of the information age, too often the focus is on the "OO" of observing and ordering and not the "DA" of deciding and acting. Boyd's OODA loop is the basis for the joint definition of decision making cycle.¹⁷

4. **Law of Diminishing Returns.** The Law of Diminishing Returns in thought refers to the time sensitive nature, and the absence of perfect information, within the context of military decisions. There is an optimal time to make a decision based on information and the ability to decide. However, the problem for the military is that the need for a decision may come before you achieve the optimum point. Dr. Kindler, author of *Risk Taking: A Guide for Decision Makers*, made an observation that as the amount of

information increases, the cost of collecting the information increases geometrically, but the value of the information levels out.¹⁸

Chapter II. What is the individual intellectual thought process and how is it developed?

There is little value in applying any evaluation criteria to decision making, either in historical case studies or experimental research, without first examining the theories of thought and deciding. The initial step in assessing whether the users of information technology systems will develop the situational understanding and visualization to enhance the battlefield decision making capabilities is to identify the essential elements of an individual thought process that would lead one to understanding and action. This chapter establishes the basis of cognitive thought by defining intellectual development, the corresponding components of a thought process, and the creation of a processing scheme known as a mental model.

Defining Intellectual Development. Although some thought processes are innate, decision making skills are developed. This monograph is intended to foster an understanding of how we think and what we can do to affect change in others. The first task then is to define development and intellectual development, then trace the necessary theoretical foundations of intellectual development, and finally outline the requisite theories for application in this paper. Understanding that no single perspective is capable of explaining or defining everything, it will be necessary to integrate a number of theories from psychology, philosophy, and engineering into a single concept of intellectual development.

Development is a hierarchical process, in which each step is seen as a confrontational challenge to a person's previous thought structure that requires extension and redefinition of individual attitudes or competencies in the midst of increasing uncertainty and complexity, to again achieve an internal balance.¹⁹ In order to achieve **intellectual development**, one either adjusts existing thought structures (or 'mental models' which will be defined later) or develops a new structure to form an understanding and gain meaning for a given situation or context. Each individual processes information differently, but research indicates that similar experiences within a contextual domain result in similar ordering of thought.²⁰

Although this monograph assumes primarily a developmental perspective, there are notable influences from learning theorists that must be addressed because the transference of many military skills is

best accomplished through experience. There are significant differences between the developmental and learning theories, but they are not mutually exclusive. Developmental theorists tend to focus on qualitative advancement through progressive stages to a more effective or higher state of thinking about the individual, the environment, and the relationship between the two. Learning theorists center on the systematic acquisition of skills through study, instruction or experience. Development infers learning occurred, while learning does not infer that an individual developed.

Albert Bandura, a behaviorist and author of *The Social Learning Theory*, posited that people are neither driven singularly by internal forces nor does their environment manipulate them. "Rather, psychological functioning is a continuous reciprocal interaction of personal and environmental determinants. Within this approach, symbolic, vicarious, and self-regulatory processes assume a prominent role."²¹ In simplest terms, man is a social being whose thought process results from the collective experiential activity of the society in which he lives. Experiential learning may be seen as the accumulation of cognitive determinants and relationships among objects, events, and particular situations. Social Learning Theory in and of itself may not account for innate thought processes, or the fact that people are capable of "overriding the best-laid plans of contiguity, reinforcements, and example by their idiosyncratic perceptions."²²

Although based in the traditions of Bandura and behaviorism, Arnold A. Lazarus' Multimodal Therapy subscribes to no particular "dogma other than the principles of theoretical parsimony and therapeutic effectiveness."²³ Lazarus, a clinical psychologist, adapts a systems approach to his theory, incorporating behaviors, the affective domain, sensation, imagery, cognition, and relationships -- taking a minimalist approach to theory and focusing primarily on treating the needs of the client. Given this more holistic and humanistic viewpoint, what we are is more than just the overt behavior of individuals. People do not respond to some real environment but rather to their perceived environment. Learning theories tend to explain and predict the psychology of human behavior based on environmental and cognitive determinants. On the other hand, developmental theories focus generally on explaining and predicting the psychology of thought. This discussion of development then, will continue based on perceptions, or how the individual recognizes and derives meaning, rather than learning.²⁴

Intellectual development is a hierarchical changing of existing thought structures or forming new thought structures to make sense of a situation or context. Intellectual development may be divided into two areas: What you know and how you think. What you know, the development of verbal, quantitative, and subject matter competence, may be identified through standardized tests or evaluations. These objective measurement indices are easier to administer and score than subjective means, so many rely on these tools to assess development. The skill to acquire information and achieve competence is essential for many tasks at many levels in the Army and in life. However from a developmental perspective, and for the primary purpose of this monograph, what you know is not as critical or lasting as how you think.

How an individual thinks, reasons, or judges -- the essence of intellectual development -- is by far more difficult to understand or assess than what someone knows. The field of philosophy has existed for over 2600 years and the science of psychology is almost two hundred years old yet there is no universal consensus on matters of thought. Within the field of philosophy, one divides the study of decision making into discovery of human mental process and motivation. Although ethics, morality, or personal satisfaction affect an individual's reason or judgment -- motivation to act through values and virtues is outside the scope of this research. The intended focus of the monograph remains on the process or intellectual activity of decision making.

To begin laying the necessary theoretical foundations of intellectual development, one should first address, and then set aside, the nature versus nurture debate. Decision makers are neither completely born nor made. In the fourth century BC, Greek philosopher Plato wrote *The Republic*, which discussed the nature of justice, the range of human knowledge, the purpose of education. Plato offered an argument that thoughts and values are innate and not gained from experience. In contrast, seventeenth century English philosopher John Locke argued, in his "Essay Concerning Human Understanding," that there is no thought or action that does not originate from experience. Eighteenth century German philosopher Immanuel Kant, in his "Critique of Pure Reason," sought to provide resolution on this nature versus nurture controversy and bridge the gap between rationalism and empiricism. He argued simply that nature provides the structure for thought and action. Experience provides the content.²⁵ Having thus disposed of the 2000 year long

nature versus nurture debate, one can proceed with a discussion on the theoretical foundations of intellectual development.

Kant influenced another German philosopher, Georg Wilhelm Friedrich Hegel. Hegel popularized the concept of the dialectic, which serves as the basis of many theories in philosophy, political science and psychology. In this dialectic, an idea or thesis, contains within itself an opposing idea, called an antithesis. From conflict between these opposing concepts arises a third, totally new thought, the synthesis. Adding to this thought, throughout the nineteenth century, various thinkers discovered many secrets of the functioning of the human mind: the reflex action, the electrical nature of nerve impulses, the velocity and conduction of nerve impulses, color perception, and the resonance theory of hearing. All of these discoveries led to the developing field of psychology.²⁶

Within the twentieth century, technological advances improved the biological and physiological researcher's ability to study the mental tasks and cognitive processes of the mind. Although cognitive psychologists have discredited or dismissed most of Sigmund Freud's therapeutic work in psychoanalysis and dream interpretation, his contribution of understanding the mind's conscious, preconscious and subconscious are still relevant when mapping brain functions, memory, and rationalization.²⁷ Similarly, Swiss psychologist Jean Piaget studied the development of children's thought about dreams and morals in an attempt to bridge philosophy with science. However, his lasting contribution to cognitive psychology and intellectual development occurred when Piaget shifted his emphasis to how children develop perceptions and skills in mathematics and science. His dialectic thought process was of accommodation (adapting existing structures to fit new information) and assimilation (adjusting new information to fit current structures) as an individual moves to keep balance (equilibration).²⁸

Although not as well-known as Piaget's Cognitive Developmental Theory, or Freud's Psychoanalytic Theory, Austrian Heinz Werner's contribution of what is known as the orthogenic principle more completely describes the "how" and not merely the "what" of development. Werner's Organismic and Comparative Theory also offers a dialectic thought process based on his orthogenic principle, that development occurs from a state of relative lack of differentiation, to a state of increasing differentiation and hierarchic integration. Werner's work directly influenced two theorists who have focused their efforts

on the intellectual development of college students, Arthur W. Chickering and William G. Perry, Jr.²⁹ The study of college and graduate student development closely aligns with intellectual development within the profession of arms because generally the institutional purpose and goal of both groups is to develop a sense of individual and collective identity, foster life and career experience, while training and educating within a specific field.

Chickering, a Distinguished Professor of Higher Education at the University of Memphis, contributed the theory that an individual develops an identity through achieving competency, finding a purpose, and mastering thought processes. Chickering described seven vectors of change that identify how, through structured educational experience, an institution or organization can foster the higher professional, social and cognitive processes of development.³⁰ Perry, a Harvard University professor, studied the linkages between moral and intellectual development. Perry argued that intellectual development takes place in the building of commitment to value sets and the forms in which an individual processes information about the world. His fundamental belief was that, to understand how someone thinks, you must first get them to think. Perry's contribution to developmental theory was a scheme for evaluating the analytic thought structure of college age students. His stages of development centered on the self-prospective from the basic duality of a black and white world to one of commitment to a complex hierarchical value set.³¹

In summary, intellectual development is the conscious, hierarchical process of confronting a person's previous thought structure that requires extension and redefinition of individual attitudes or competencies in the midst of increasing uncertainty and complexity. One fosters development through the creation of an abstract environment that explicitly challenges the individual's experience and provides the structure for thought and action. The current body of evidence on college and graduate student intellectual development reflects this process of synthesis and design, serving as a basis of argument in this paper and for further research within the military profession.

Components of a Thought Process: Perceptions, Patterns, and Predictions. Given the above

understanding of intellectual development, the next step is to analyze the components of the cognitive thought process. The cognitive developmental approach of organizing and processing of information is evidenced in almost any association between a stimulus and response is a thought. This section explains how an individual organizes thoughts, concepts and ideas to form predictions, through perceptions and patterns. Psychologists, in general, attempt to understand how people learn and reason about physical systems. Their research describes in detail the event of human reasoning essential to understanding the decision making process.³² The methodologies for explanation are eclectic and interdisciplinary.

Cognitive psychology has its origins in economics, statistics, mathematics, and philosophy. Developing thought from experience is inductive; that is, one experiences specific instances or cases and heuristics are developed to provide some generality for dealing with them. The mind receives these instances or cases in the form of a sensory perception. Heuristics are mental shortcuts, the linking mechanisms that connect the perceptions to stored memory, and form patterns. The heuristics are specific rules that group patterns of thought and shape our mental models.³³ This section explains each of these matters in detail.

There is an important difference between perception and conception. In its most general terms, a perception is an instantaneous intuitive recognition or appreciation – including the sixth sense of insight. Conception is the formulation of an idea, a general notion. A conception is a more time consuming grouping of patterns or even models within multiple perspectives. One may conclude that individuals develop perceptions and preferences on issues that are familiar, simple, and directly experienced.³⁴ Individuals develop heuristics that provide self-justifiable answers to questions posed by the perceptions. The strength of these internal rules comes from their development and application to the settings found in a simple and unchanging society with repetitive problems. As the situation becomes more complex and ill-defined, an individual's rules are then, untested, and perhaps untestable.³⁵ It is then that one must rely on intuition and develop a conception to consider multiple perspectives simultaneously.

One theorist whose ideas crossed many academic disciplines and focused on the conceptualization of complex systems was Ludwig von Bertalanffy. Bertalanffy was a Viennese professor of biology who

emigrated to Canada in 1949. In his book, *The General Systems Theory*, life was a system of self-organization, or developmental unfolding at progressively higher levels of differentiation and organized complexity (integration). But within the context of a systems approach, wholes are not reducible to separate parts and their developmental forms are qualitatively different from earlier forms.³⁶ One could see the direct linkages to Bertalanffy's theory from both Werner's dialectic and the holistic approach of the Gestalt tradition (a further discussion of Gestalt theory is in the following section), but extending the application to an expansive systems approach to all development.

But are all perceptions true and do they all contribute to cognitive thought and intellectual development? There is an expression, "Believe half of what you see and none of what you hear." We are told many times from our youth that our senses deceive us. One may see this as one of two possible processes and outcomes. One possibility is located in our ability to choose the sub-optimal (viable options, but not the best) answers based on our heuristics.³⁷ A human mind may take a mental short cut to resolve perceptions quickly, rather than completely. As psychologist Leon Festinger's theory of cognitive dissonance posits, if a person's perceptions are not psychologically consistent with one another, he will attempt to make them consistent and reduce the psychological distress.³⁸

Another possibility is that, the cognitive perception triggers a pattern or heuristic within a mental model that differs from reality, thus creating an illusion. Illusions are simply discrepancies from the truth caused by our minds. Massimo Piatelli-Palmarini stated in his book, *Inevitable Illusions*, that, "Between rationality and our cognitive pride, we will chose the latter, and will to pay whatever the price for so doing. We are instinctively poor evaluators of probability and usually poor at choosing between alternative possibilities."³⁹

We become comfortable with what we perceive, creating and relying on tunnels of the mind. Although we rely on intuition to solve complex, ill-defined problems, many decisions made on the basis of intuition before knowledge may not be good. Piatelli-Palmarini's solution is that we should be conscious of the elementary mechanisms, many of them innate, of our thought. Reason, or rationality posed against irrationality, through the application of heuristics, may cause problems when dealing with uncertainty.⁴⁰ This monograph discusses uncertainty and ill-defined problems in subsequent sections.

If, from a mechanistic perspective, perception is the entire process of transforming a complex input into appropriate names, descriptions, behaviors, or other outputs, then patterns may be any combination of qualities or acts forming a characteristic arrangement, designed to serve as a model. These are the basic premises in Leonard Uhr's book *Pattern Recognition, Learning, and Thought*, which link the study of cognitive psychology to the use of computer programmed models for higher mental processes. Uhr, of the University of Wisconsin, explained pattern recognition and perceptual learning as the assignment of the appropriate output. He described his theory of learning as a "many to one mapping from the set of all the variant instances of the different patterns that can be identified to the set of these patterns' names."⁴¹

There have been many books on the search for artificial intelligence, M. Mitchell Waldrop's *Complexity*,² and Christopher G. Langston's *Artificial Life*,² to name two. Few focus on the development of the thought process computers attempt to emulate. However, a 1970 translation of Russian scientist M. Bongard's *Pattern Recognition*, details the advances of computer technology in simulating cognitive thought, without getting lost in technological details. Bongard posited that pattern recognition is the combination of all processes in the system, including the learning process.⁴² Think about what may be considered a simple mental task, such as reading this text. Several thousand computer programs have been written just to detect characters and formulate text. With all the advances of the past forty years, none are 100% accurate for the varied type sets and sizes -- and that is scanning two-dimensional typed lines.

Pattern recognition is best explained through a discussion of Gestalt theory. Heinz Werner, mentioned earlier, was strongly influence by Gestalt psychology and the concept that individual's desire to perceive whole forms. Once an individual develops the psychological perception, the whole forms cannot be analyzed subsequently into component pieces. The pattern is more than the parts. A perception would trigger a linking heuristic and associated mental models. For example, Gestalt theory posits that humans have a tendency to close patterns, such as, if a figure was drawn with only dashed lines or dots, our minds would complete the figure into a solid shape.⁴³ Also, if a series of electronic sensors were placed on an individual's joints, the messages digitized, and then played on a computer screen, the brain would "see" the moving dots as a person walking. What one should take away from Gestalt theory is the notion that the

learning process is open-ended. Our minds will make the connections, assumptions, or leaps to fill in what is missing. Therefore a learner should not, or cannot be sure that he has identified every implicit assumption.⁴⁴ As evidenced in this brief discussion of perceptions and patterns, the formulation of mental models, specifically multiple models is a very amorphous subject.⁴⁵

Thus one may now see how an individual organizes thoughts, concepts and ideas through perceptions, patterns and predictions. A perception is an instantaneous stimulus, being either a recognition or appreciation, that fosters thought. The associated thought, or heuristic, is a linking mechanism that connects the perceptions to stored memory and forms patterns. Patterns simply are the combination of perceptions and additional heuristics that form a characteristic arrangement of qualities. Predictions, or mental models, are the assignment of appropriate names, descriptions, behaviors, or actions that shape our understanding of the world. However, the brain does not function solely in a linear fashion. Many heuristics, perceptions, and patterns influence the thought process simultaneously from varied perspectives. A conception is the grouping of patterns, predictions and models from multiple perspectives.

Defining Mental Models: Patterns of perceptions. If perceptions and patterns lead to the formulation of mental models, what are mental models and how do they work? Simply defined, "Mental models are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action."⁴⁶ Mental models are naturally evolving constructs that change with respect to the individual's experience, location, and disposition. The application of a mental model explains how we decide and take action. Understanding, achieved through the use of mental models, increases the ability to simulate, teach, develop, and test for knowledge.⁴⁷

Although taken by some to have a negative connotation, mental models are not inherently or necessarily bad. One must understand which models he or she prefers, ensure the decision maker uses more than one model, and understand the limitations of any thought system. A skill for the individual to develop is the ability to recognize the patterns of thought and the dynamic complexity within relationships.⁴⁸ Knowing the existence of a model or models is important, but understanding the second and third order effects of applying these models is of greater importance. With regard to understanding the

application of mental models on the individual level, Michael D. Williams, of the Xerox Palo Alto Research Center, James D. Hollan, of the Navy Personnel Research and Development Center, Albert L. Stevens, of Bolt Beranek and Newman noted that, as with computer code, a mental model may be composed of autonomous objects with an associated logic flow. They added that mental models are "runnable" by means of local qualitative inferences, and that they can be decomposed. Given this information, it would appear that a computer could replicate some linear and analytic thought processes.⁴⁹

How are mental models formed? If models are collective groupings of perceptions and patterns, then how are they created in our minds? In order to reason, humans form and apply mental models. The mind maps perceptions, linkages and patterns to satisfy the requirement for "prediction, explanation, and invention."⁵⁰ Central to this conception of mental models is the notion of autonomous objects. An autonomous object is a mental object with an explicit representation of its heuristics and linkages to other objects, and a set of internal parameters. A mental model is a collection of "connected" autonomous objects that have definite boundaries. Williams, Hollan, and Stevens argued that with each autonomous object is a unique set of rules that modify its parameters and thus specify its behavior.⁵¹ As the behavior and new perceptions modify the mental model and its heuristics, either a new autonomous object develops, or the mind redefines the object boundary. Thus, similar to the theories of Piaget and Werner, mental models develop through increasing differentiation and integration, as well as through assimilation and accommodation, to achieve a greater understanding. The central argument is that the existing mental structure must be challenged to achieve thought and development.

How do we use mental models? Accepting that mental models reflect beliefs about the physical system, a corresponding value between the parameters, and the observable states of the mental model, what should a model do for us? First and foremost, the mental model should have some predictive power to allow the person to develop inferences, gain understanding, and anticipate the behavior of a physical system.⁵² In addition, they can serve as mnemonic devices to facilitate remembering.⁵³ However, we should accept that people's mental models are apt to be deficient in a number of ways, perhaps including contradictory, erroneous, and unnecessary concepts.⁵⁴ For example, humans are not perfect due to emotion or bias, and lack of knowledge or incompetence, in every domain of knowledge. We should develop

systems that foster coherent mental models that are appropriate for the fact that each person is unique -- design a conceptual reality for the messy, sloppy, incomplete, and indistinct structures that people really have.⁵⁵

If each individual forms models differently, how can we explain expertise in specific or varied domains? Dedre Gentner, of Bolt Beranek and Newman, and Donald Gentner, of the University of California, San Diego, conclude that, "the use of different analogies leads to systematic differences in the patterns of inferences in the target domain."⁵⁶ They suggest people use analogies to help structure unfamiliar domains. This is what Piaget meant by assimilation and accommodation, adjusting a known structure to the unfamiliar or unknown situation. Gentner and Gentner posit the extensive use of analogies in common speech suggests that the analogies are used in thinking. However, we cannot make this leap to thought until it is proven that the analogy is not an idiomatic phrase, but really the results of independent inferential processes.⁵⁷

There are advantages and disadvantages associated with the application of mental models. Donald A. Norman, a professor at the University of California, San Diego, observed people interacting with technical devices: talking mainly of calculator usage, computers, digital watches, text editors, aircraft, video cameras. Within the framework of the information age and the Army's current efforts toward digitization, Norman's work would be of particular interest. He listed six generally negative findings.

1. Mental models are incomplete.
2. People's abilities to "run" their models are severely limited.
3. Mental models are unstable: People forget the details of the system they are using, especially when those details (or the whole system) have not been used for some period.
4. Mental models do not have firm boundaries: similar devices and operations get confused with one another.
5. Mental models are "unscientific": People maintain "superstitious" behavior patterns even when they know they are unneeded because they cost little in physical effort and save mental effort.
6. Mental models are parsimonious: Often people do extra physical operations rather than the mental planning that would allow them to avoid those actions; they are willing to trade-off extra physical action for reduced mental complexity. This is especially true where the extra actions allow one simplified rule to apply to a variety of devices, thus minimizing the chances for confusions.⁵⁸

Sometimes solutions to problems work and sometimes they fail. Norman's findings clearly identify some of the weaknesses within mental models that inspired Senge's work studying the dynamics of the business world.⁵⁹

The application of mental models allows a person to develop inferences, gain understanding, and anticipate the behavior of a physical system. The extent to which these models predict is a function of the accuracy of the original perceptions, the formulation of correct patterns, and the application of the right model. Changes to mental models in a complex, adaptive environment lead one to see that the body of experiential knowledge consists of fragments of mental models previously known and used.⁶⁰ Mental models also serve as mnemonic devices to facilitate remembering and decision making. Through the application of mental models, one establishes a framework that limits thought through direction and structure. But, that same framework facilitates thought and the ability to develop new models. The study of mental models and decision making by itself appears to be a theory of best action, not always of rational action.

This chapter established a basis for understanding cognitive thought by defining intellectual development, the corresponding components of a cognitive thought process, and the creation of a processing scheme known as a mental model. From this concept of how an individual develops, thinks, and decides, the focus of the monograph shifts to narrow and qualify the thought process within the context of decision making by asking, how does an individual develop expertise in decision making?

Chapter III. What is expert decision making and how does it apply to the military?

Know what you know and know what you do not know. -- George S. Patton Jr.

In general, skill is competent excellence fostered through the course of training, experience, or talent.⁶¹ Given competent decision making as a desired skill for members of the military profession, how does one develop from a novice to a subject matter expert? The next supporting argument is intended to identify the essential elements of expert decision making.

Expert Decision Making: Linkages, Assumptions, Possibilities, and Confidence. Patton's dictum for his subordinates, quoted above, could easily translate into this discussion on expert knowledge and decision making. Experts tend to have an ability to recall what they know, as well have a grasp of what they do not know – what information is required. One could view knowledge as a collection of beliefs with varying

strengths of certainty and with some affective quality.⁶² However, defining the continuum between a novice and an expert is not a matter of acquiring more information or mastering a particular skill set. In normal parlance, expertise develops as the amount of information stored increases within a field or domain and the knowledge becomes increasingly better organized.⁶³ The emphasis of this paper is on the combination of information and the organization of it -- the difference between knowing "that" versus knowing "how."

In *Mind Over Machine*, Hubert L. and Stuart A. Dreyfus detail five possible stages of knowledge acquisition: novice, advanced beginner, competent, proficient, and expert (See Annex A, Glossary for a brief explanation of the five stages). The basic premise of their book is the existence of a gradual process of development, "as human beings acquire a skill through instruction and experience, they do not appear to leap suddenly from rule guided "knowing that" to experienced based "know how."⁶⁴ Using four categories to delineate the individual's perspective and decision making process, Dreyfus and Dreyfus frame the distinctions between a detached, rule oriented novice and involved, intuitive expert. As we focus on an individual's ability to acquire information and being able to use it, practice becomes essential for developing and maintaining know-how.⁶⁵

The Dreyfus' work is relevant because of the distinction drawn between computing and thinking. There is more to intelligence than calculative rationality. Intelligence includes an area of thought beyond the conscious level. Although irrational behavior is not recommended, there may be a vast area of thought that could be referred to as "arational." Arational could be those "actions without conscious analytic decomposition and recombination."⁶⁶ Experts appear to have this ability to process more abstract information without any apparent thought.⁶⁷ These observations will become critical later during the discussion on the limitations of the computer or artificial intelligence.

One may describe and define an expert simply as a person with a special skill or technical knowledge in a specific field. Michelene T.H. Chi and Robert Glaser, in *The Nature of Expertise*, tie the study of expertise to the rise in cognitive psychology and artificial intelligence in the nineteen-sixties that was also the impetus for the development of studying mental models.⁶⁸ Glaser and Chi, both of the University of Pittsburgh, highlight and generalize on the relevant characteristics of experts.

1. Experts excel mainly in their own domains.
2. Experts perceive large meaningful patterns in their domain.
3. Experts are fast; they are faster than novices at performing the skills of their domain are, and they quickly solve problems with little error.
4. Experts have superior short-term and long-term memory.
5. Experts see and represent a problem in their domain at a deeper (more principled) level than novices; novices tend to represent a problem at a superficial level.
6. Experts spend a great deal of time analyzing a problem qualitatively.
7. Experts have strong monitoring skills.⁶⁹

If these are the general abilities of an expert, what makes an expert decision maker? Essential to this discussion are: the ability to develop large patterns, superior memory skills, the ability to examine problems at the complex level, and the practice of spending more time identifying the problem. These four topics deal primarily with how information may be organized.

Andrea A. diSessa of MIT points out that the "difference between novices and experts, indeed between common sense and scientific reasoning, ... is not so much the character or even content of [their] knowledge, but rather its organization. Experts have a vastly deeper and more complex priority system."⁷⁰ Whether in chess, physics or electric circuitry, the body of research demonstrates experts perceive and process patterns of information that represent functional units in their domains. Experts "see" systems in groupings, understand the linkages that hold the system in place, and do so with a great deal of confidence. Novices lack this ability.⁷¹

Expert knowledge may also rest more in an elaborate semantic memory than in a general reasoning process. Patterns and models are coded through heuristics. Individuals demonstrate such knowledge and recall, not only in what may be considered the domain of expert performance, but also in a fundamental skill like reading. The varying degrees are whether one sees curved and straight lines, to letters forming words, to complete words, to complete sentences or paragraphs or pages. The expert is readily able to access a "complex network without any conscious representation of the search processes that go on in its retrieval."⁷² The challenge to produce an expert may not be in selecting a person who has a special ability, but to create and maintain the motivation needed for long-term training to master the skills.⁷³

Superior memory skills are related to the ability to perceive large patterns in a domain. Experts exploit long term memory to expand working memory capacity in terms of three principles of skilled

memory: mnemonic encoding, an advanced retrieval structure and a rapid processing system.⁷⁴ Most research indicates that that average human being can recall or maintain up to ten independent items within their active memory at a given point in time. Through the principles of skilled memory, those ten items could be an encoded message holding a thousand other pieces of information. Skilled memory theory holds that, in principle, people can learn to hold virtually unlimited amounts of information in their active memory with sufficient practice.⁷⁵

Most of the research indicates that expert performance on “easy” problems may be attributed generally to memory. However, memory is a developed skill and one of the best illustrations of expert decision making and the power of memory is the game of chess. Herbert Simon, noted organizational psychologist and author, reasoned that masters level chess players spend between 10,000 to 20,000 hours staring at chess positions. This could equate to wargaming a battle with arrayed forces for forty hours per week for thirty-three weeks for ten years. Simon also went on to add that a master has committed to memory about 50,000 visual patterns of the chess board and pieces.⁷⁶

Memory and large patterns alone would not allow an expert to solve complex problems. Eric J. Johnson, of the Wharton School, University of Pennsylvania, wrote that experts in general appear to make more accurate decisions than do other people in environments that are characterized by uncertain information. Experts solve complex problems because they search for different information (focus on diagnostic information), with different patterns of search (active, flexible).⁷⁷ Experts do not rush into solving the problem, they focus their initial efforts on problem identification.

Given these general qualities of experts, what then are the problem solving techniques of experts versus novices? Because of an ability to rapidly perceive a complex situation and modify mental models to meet varied perceptions and patterns, the expert can adapt easily and infer to the unclear situation, changes in rules, or whatever. The novice struggles with unclear problem presentation. “The combination of more abstract knowledge and greater connectivity of knowledge means the expert is able to make more inferences than the novice.”⁷⁸ Novices and experts tend to use similar problem solving strategies when faced with simple problems in a common domain. However, the expert’s knowledge and organization normally permit greater agility, speed, and depth in the generation of a solution set.⁷⁹

Experts have a distinct advantage over the novice when the routine tasks require no time for thought. They use their memory to aid in the decision making. "Experts use retrieval structures effectively because they have learned the processing demands of a task and which information is essential for successful performance."⁸⁰ The advantage is in knowing the steps of problem identification: clearly identifying the difficult versus the easy, the complex versus the routine. The novice lacks the experience within the domain to do it.⁸¹

How do we define military expertise and what is the importance of developing expertise in the military? For example: given a basic scenario on any terrain, develop and choose a course of action. The research showed that the influence of experience on accuracy in predicting battle outcomes was dependent on the inherent predictability of the scenario. Experienced officers did better on a normal mission plan; they were less accurate on one that was poorly executed. A number of similar findings have also occurred in other domains.⁸² Experienced officers may rely more on intuition than on analysis and may not think explicitly about all the chance events that might occur, either in the present or the future.⁸³ One reason may be that, "The more skilled we become, the more we live in the present, recognizing that if we keep sensitive fingers on the pulse of current events and respond well now, the future will take care of itself."⁸⁴ The expert may also plan for the most likely outcome and be able to adapt to the unforeseen. An expert possesses the ability to select the optimal solution for both the current and future states, understanding that neither solution may be the best possible outcome in and of itself.

One other important observation of Simon was the changing of the decision making process when encountering ill-defined problems. His plea was for, "a description of the choice process that recognizes that alternatives are not given but must be sought."⁸⁵ Chi and Glaser presented a possible solution to Simon's request,

As experts proceed, structure is obtained by decomposing the ill-structured problem into a set of well-structured problems which are then solved. To be able to do this it is asserted here, the expert must have a relatively larger amount of information in memory so that they can utilize appropriate components of knowledge to organize the problem solution.⁸⁶

For the purposes of this monograph, a well-defined problem is as follows:

1. Goal, criterion for judging outcomes and states
2. Initial state, starting situation, and resources
3. Admissible operations, rules for application to transform states and resources

4. Constraints, on what must be done along the way, final states to be reached
5. Outcome, a final state or solution.⁸⁷

The Military Decision Making Process (MDMP) is an attempt to make ill-defined problems into well-defined problems through a discrete thought process. The Military Decision Making Process is, by definition, “A single, established, and proven analytical process. The MDMP is an adaptation of the Army’s analytical approach to problem solving.”⁸⁸ The process is time consuming but focuses on detailed integration, synchronization, and coordination. Experience in the decision making process develops the methods for asking the right questions, means of monitoring information flow, and knowledge of certain consequences. An ill-structured problem may just be a matter of the problem solver’s ability to frame the situation and create a solution. The difficulty remains that all the research indicates that expertise is highly perishable and domain specific, and not transferable from one skill set to another.⁸⁹

Computer Assisted Decision Making. Because experts tend to view the world in patterns or chunks, seem to possess both long and short term memory, and have the ability to process large amounts of information, computer scientists have been trying to get computers to model the same “expert system.” Artificial intelligence seemed only years away in the nineteen-fifties. Today, the more we understand of the complexities of the human thought process, the further we move away from re-creating the human brain. Within some very specific domains, machines “that embody knowledge and apply it can approximate the performance of human experts. As a consequence, expert-system building has concentrated on the knowledge that underlies human expertise and has given less emphasis to the significance of domain-independent problem-solving heuristics.”⁹⁰

If machines attempt to approximate human thought, how do machines learn? One could consider three possible types of learning when dealing with a machine: establishing a connection between the structure of the device and its function; making the structure-function connection more robust by making implicit assumptions explicit; and, storing of the results of the projection problem-solving on the intrinsic mechanism.⁹¹ A computer’s information is generally restricted to the knowledge engineer or programmer. “The knowledge engineer does this (codifying knowledge to emulate human inferential reasoning) by reducing the expert’s wisdom to a series of interconnected generalized rules called the “knowledge base.”

A separate computer program called the inferential engine is used to search the knowledge base and draw judgments.”⁹² However advanced the computers thought may be, it will always be guided by rules or algorithms, and therefore not able to develop. Even cyberspace maverick Kevin Kelly, in his book *Out of Control*, admits that evolving, learning machines are not in our immediate future, citing the history of evolution in millions and billions of years.⁹³

Therefore, if a human-machine is not on the foreseeable horizon, a comparison of the strengths and weaknesses of humans, computers, and the human-computer interaction may be important at this time. For example we can take a simplistic view. Computers do not get tired and human beings can act on intuition.⁹⁴ But let us focus on the key elements of what was presented thus far. First with respect to pattern recognition. “Pattern-matching is the key to comprehending speech, finding tanks camouflaged beneath a tree, or spotting flaws in manufactured products. Conventional computers, no matter how powerful, cannot equal that ability.”⁹⁵ Second, we can examine a comparison in terms of organization and ill-defined problems. A computer is more precise and predicable, but precision and predictability are not what human intelligence is about. “Our intuitive expertise, irreducible to rules, casts the weight on the side of the human mind.”⁹⁶ To put this problem another way: Intuitive human heuristics can be exceptions to the rules. Moreover, there is not just one exception to each rule, but several, and all the rules for dealing with the exceptions have more exceptions.⁹⁷ “Specifically, if an expert system attempts to mimic a human expert, it may fail to exploit much of the information available in the task.”⁹⁸ Third, computers are reliant upon programmers who cannot codify most of the human experience. A programmer develops codes that enable the computers to play tic-tac-toe, or checkers or chess because the games have distinct rules and definitive strategies. However, “the most important observations and turns of skill in all sorts of trades and professions are as yet unwritten. This fact is proved by experience when, passing from theory to practice, we desire to accomplish something. Of course, we can also write up this practice, since it is at bottom just another theory more complex and particular.”⁹⁹

Expert systems modeling suffers because the knowledge of any given human may not fit readily into any particular structure. Cognitive structures differ from one individual to another. Moreover, important knowledge may be “lost in the translation” as qualitative perceptions of uncertainty, value, etc.

are forced into the numerical form of probabilities or utilities.¹⁰⁰ Based on this discussion we should incorporate the strengths of both humans and computers, but with the human mind as the decision maker and the computer as the decision aid.

*"With 2000 years of examples behind us we have no excuse when fighting for not fighting well."
-- TE Lawrence*

Military Decision Making. Our nation expects a great deal from her military, just as all proud states do. She demands that the military not make the mistakes of the last war. A state anticipates that armed forces assimilate the lessons from as many experiences as possible so as not to repeat the mistakes of others. It also expects the military to accommodate change by developing new procedures to address new problems. Given the rapidly changing world we live in today, as Simon said, we need a description of the choice process that recognizes that alternatives are not given but must be sought in order to deal with the complexities of ill-defined problems. As the Prussian philosopher wrote, "War is the province of uncertainty: three-fourths of those things upon which action in war must be calculated, are hidden more or less in the clouds of greater uncertainty."¹⁰¹ What do we really need to make a decision, if what Clausewitz said is still valid?

As the military acquires increasingly sophisticated information processing technologies while conducting ever more complex and diverse missions of national security, there is a growing internal debate over the intellectual basis of the command and control (C²) process. Attached in Annex B, Decision Making Paradigms, are just a sampling of the myriad of models and paradigms involved in the C² process. As Israel Mayk and Izhak Rubin have presented, there is no commonly understood vocabulary or framework for "analyzing, designing, or evaluating command and control systems."¹⁰² However, each system, model or paradigm, may be reduced to the following: "(1) a mission is articulated, (2) plans are drawn and (3) operations orders are issued for execution."¹⁰³ The final diagram of Annex B is the author's depiction of the aggregate of command and control systems merged with decision making theory. This paradigm takes into account indecision, inexperience, and uncertainty in a time constrained environment.

David Noble, principal investigator in the Office of Naval Research program in distributed tactical decision making, and Ronald Mullen, senior systems engineer at Science Applications International

Corporation, examined initiative oriented warfighting skills and the tenets of AirLand Battle. As one would expect, they concluded logically that centralized planning and decentralized execution truly depends on the initiative of subordinates to make independent decisions. Distributed Decision Making is built upon a common understanding of all decision makers of the commander's intent, a common plan and goal, that specifies of what each individual should do in various "standard" situations. The important revelation is that the decision maker should focus on three layers: a feature recognition layer, a feature evaluation and combination layer, and an action and inference layer.¹⁰⁴

It may be a rational assumption that if uncertainty is fundamental in warfare, then the more information decision makers receive, the more uncertainty may decrease. However, as time increases, the uncertainty will normally approach some minimum value and the cost of gaining any additional information is very high.¹⁰⁵ Often, the hands of fate close this window of opportunity before the uncertainty reaches an acceptable level for the decision maker. At the decision making level, we must remember that we are dealing with an intelligent adversary and consider his possible reactions to our strategies.¹⁰⁶

Gary A. Klein, President of Klein Associates, studying ways to elicit knowledge and applying these data for training, decision support systems, and expert systems suggested a recognition-primed decision (RPD) model of naturalistic decision making. "More than one strategy exists for making decisions. There are times when analytical approaches are best and other times when they are just not appropriate, and recognition approaches are needed."¹⁰⁷ If a decision maker has the advantages of time and information, an analytical approach works best. If time is critical and the situation is ill-defined, a recognition approach may achieve better results.

Klein's research studied fire ground commanders (fire station leaders and fire truck team chiefs) who averaged twenty-three years experience. Given the inherent dangers of fire fighting, the selfless nature of saving other human beings, and the level of responsibility of the subjects, Klein's research presents a cogent argument for military decision making. He tested a possible 156 decision points using the interview technique to examine reactions to both critical and nonroutine incidents. No commander selected a predefined option in any of the scenarios. Specifically, within the nonroutine incidents, only

twenty percent reported any attempt to deliberate between options. Instead commanders relied on their experience to recognize an incident as familiar, carrying with it a typical way of reacting. “They told us that they rarely made decisions, which really meant that they rarely deliberated between options. There was not the time or the need. The vast majority of their decisions were made in less than one minute.”¹⁰⁸

Klein concluded that, “The decision making process begins with a pattern recognition. The decision maker uses all of the experience gleaned from years of practice to view an event as typical in some way that resembles a judgment of prototypicality.”¹⁰⁹ Other studies have shown that the analytical decision making process and strategy is not effective when there is less than one minute to respond.¹¹⁰

If our expected decision making process may last less than one minute, how should a leader develop enemy courses of action? When probable enemy course of action or intent is to be assessed, three kinds of knowledge and reasoning can be brought to bear: causal, diagnostic, and projecting the enemy decision process.¹¹¹ A rapid decision making process requires the analysis of complex situations and the planning, initiation, and control of subsequent responses. All leaders conduct these activities within a time constrained environment. “The amount of information handled by decision makers is often very large and, in order to maintain performance above a certain level, organizations use decision support systems to help them accomplish their mission.”¹¹²

The history of command in warfare consists essentially of an endless quest for certainty – certainty about the state and intentions of the enemy’s forces; certainty about the manifold factors that together constitute the environment in which the war is fought, from the weather and the terrain to radioactivity and the presence of chemical warfare agents; and, last but definitely not least, certainty about the state, intentions, and activities of one’s own forces. -- Martin van Creveld, Command in War

Indecision: Paralysis by Analysis. The truth in van Creveld’s assertion is that some, not all, commanders seek certainty. Commanders who operate in the realm of expert decision making, do so not due to the certainty of all possible data, but through the development of pattern recognition and the confidence in their intuition. For those who do not demonstrate expert decision making skills, there may be a danger that the sheer wealth of information collection and processing devices to gain certainty will overwhelm analysts and intelligence systems with data. If the analysts fail to analyze, synthesis is not likely to occur and useful information will not be available for the decision maker. This would then add to the complexity and

uncertainty that are already characteristic of military operations. "This can have two negative effects. One is that the decision makers will be facing and treating even more uncertainty in their decision support information base without the appropriate tools for treating it. The other effect, which may be even more serious, is that decision makers may not face the additional uncertainty, either because they are unaware or because they simply choose to ignore it."¹¹³

It may appear that the US military remains in an industrial age paradigm. In this sense control is emphasized over command. In the decentralized simultaneity of information age operations, control may actually inhibit command and initiative. A possibility appears to be for the US military to shift its paradigm from one of command and control to one of command or control.¹¹⁴ "The seductiveness of information technology stimulates military organization orientation towards greater centralized control and more rigid hierarchical organizations instead of the desired orientation of decentralized control and more flexible organizations."¹¹⁵ Digitized systems can store and transmit data, but human minds develop knowledge and understanding. The solution is not to forsake command or control, but to improve our ability to execute both.

Digitized systems will assist the leader in making a decision, but will not make the decision for the military commander. Fortunately or unfortunately, advances in decision making technology have not progressed as rapidly as information-gathering technologies. "Technology is making more and more information available, but the commander's ability to process and act on that information is still limited to how much the commander's brain can comprehend."¹¹⁶ It is impossible for one man to know everything. The larger and more complex the forces he commands, the more true this becomes.¹¹⁷

There appears to be an element of the decision making process that some authors omit; the non-decision or no decision. Refusal, delay, or inattention are decisions not to decide. Refusal is the choice for the status quo, deny all possible offered alternatives and do nothing. A delay could be for any number of potential reasons: inspecting further alternatives; acquiring more data; evaluating all possible alternatives and outcomes; or just waiting for your answer that is currently unavailable. Inattention borders on incompetence, but it could be either allowing someone else decide or a failure to perceive an occasion for choice.¹¹⁸

Time is an essential element within the context of military decision making and the phenomenon of indecision. There exists an optimal time to make a decision based on information available and the ability of an individual to decide. The time is optimal either because obtaining additional information is impractical or impossible. Colloquially, some members of the military may refer to this time as “the good idea cutoff point.” This is a point in time when a decision must be made and action taken regardless of the arrival of new information. Sometimes this cutoff point causes a decision not to be made. In the beginning of the decision making process a cutoff point may be made to deal with ambiguity and define the problem or situation. In the middle stages of the cycle a cutoff point may be made to deal with uncertainty in the context. In the final stages of the decision making process a cutoff point may be made to deal with unacceptability, minimum criteria for success.¹¹⁹

Expert decision making is a desired skill for members of the military profession. Decision makers develop from novice to expert ability through disciplined mental training designed to improve memory, focus on problem identification, and examine complex situations. Machines are more than able to approximate competent human decision making. However, computers lack intuition to solve ill-defined problems that lack rules or predictability. The realm of military decision making lies primarily in the uncertain, the ill-defined, and the unpredictable realities of human interaction. Given these arguments, the next element in assessing whether the users of information technology systems will develop the situational understanding and visualization to enhance the battlefield decision making capabilities is to identify the requisite skills for military decision makers.

Chapter IV. What Skills Do Military Leaders Need to Achieve Battle Command in Force XXI?

Our military leadership expects Force XXI warfare to involve operations conducted in a complex, rapidly changing, and ill-defined environment. This future environment will require military commanders to execute simultaneous, integrated, and distributed operations. Force XXI warfare will be fought with weapons systems of greater lethality, which will demand correspondingly greater dispersion, and produce unprecedented volumes of fire. Integrated information age technologies will increase individual and organizational efficiency and effectiveness. Advances in technology will improve strategic, operational,

and tactical mobility, supportability, and flexibility. Technology will greatly enhance the ability to identify, engage and destroy hostile forces successfully.¹²⁰

The choppers and the spy plane, flown by U.S. Navy aviators, tried to steer the convoy clear of Somali gunfire, dodging the soldiers left and right on the labyrinthine streets. It was like negotiating a maze. But the Orion pilots were handicapped. They were not allowed to communicate directly with the convoy. Their orders were to relay all communications to the Joint Operations Center (JOC) back at the beach. So when the Orion pilots said, "Turn left," that message went first to the JOC and then to the convoy. The pilots watched with frustration as the convoy drove past the place they had directed it to turn, then, getting the delayed message, turned left down the wrong street.

There was another problem. Watching on screens, the commanders weren't hearing the pop of bullets and feeling the bone-rattling, lung-sucking blast of grenades. The convoy's progress seemed orderly. The video images weren't conveying how desperate the situation was.

-- "Blackhawk Down, Chapter 12," 27 November 1997, The Philadelphia Inquirer

The situation in Somalia demonstrated that exercising battle command in an ill-defined environment entailed more than issuing orders and required more than knowing the locations of units. As this monograph focused on the complexities of thought and decision making, one could expand the TRADOC definition of battle command to comprehend the cognitive process of military decision making and overseeing the execution of assigned missions. Battle command remains the act of achieving situational understanding, visualizing the future state, formulating the best possible plan, and directing its execution. Thus, the final step in assessing whether the users of information technology systems will develop the requisite situational understanding and visualization to enhance the battlefield decision making capabilities is to identify the skill sets that a leader should develop to exercise battle command in Force XXI.

Given the theoretical construct of the intellectual thought process, an acceptance that skill is the development of expert ability, and an understanding that expertise is the mastery of a skill set within a specific domain, one can then describe the necessary skill set for leaders of Force XXI operations. Not to trivialize or oversimplify the process, but one may see this as a hierarchical progression from the mastery of abilities linked to the development of skills and then to the creation of a complex skill set. There exist specific innate and developed abilities that are essential components of the desired intellectual skill. That is not to imply that the supporting abilities that contribute to the development of one skill are mutually exclusive from the development of other skills. Similarly, there is not an independent, linear relationship between a specific skill and the development of a skill set. The integrated linkages between the skills and

the creation of a complex mental skill set occur on multiple levels through disciplined practice and experience.

The abilities required to develop the skills for Force XXI operations are the capacity to perceive, learn, synthesize, and decide. A leader may develop a level of competency within his or her abilities, innate or learned, through practice and experience in coping with different situations, problems, or activities. The capacity to perceive requires the use of an individual's physical senses, but also the heuristics to discern the essential elements of a situation and apply an optimal pattern of thought to the given stimuli. Perceptions of individual engaged in activities of social interaction involve an appreciation for the human element of problem in terms of psychology and physiology. One has the ability to learn through assimilating and accommodating new thought patterns and mental models. An individual develops the ability to synthesize through analyzing the component elements, understanding the functions between each element, and appreciating the entirety of a complex system. The ability to decide is a function of applying the mental models, heuristics, and organizational hierarchy of judgment and intuition that lead to understanding. Given understanding and a will to act, then a leader truly has the ability to decide.

Even as an individual develops a sense of subject matter or activity competency, something is missing. The ability to think deductively and analytically is important, but these abilities are not the final extent of human thought or development. A concept of proficient thought is the capability to intuitively respond to patterns of perceptions and models without first identifying each component, a sense of association or anticipation, is a skill. Although a leader will still think analytically, proficient decision making is demonstrated when he or she has the skill to experience a problem or task from multiple perspectives simultaneously and order each based on reflective judgment. Simply, once an individual masters a specific combination of abilities, he or she then demonstrates proficiency of a certain skill.

The conditions of Force XXI operations require decision makers to develop the following nine intellectual skills. First, a leader must have the mental agility and depth of thought to visualize and anticipate new patterns, heuristics, mental models in order to develop a more complete understanding of the relationship between opposing and friendly forces, the environment, and time. Second, a leader must have the versatility of thought and imagination to maximize the advances in the area of information

technologies. Individuals must be able to recognize and change their existing fears and unrealistic expectations of technology, while understanding the capabilities that result from integrating technology with human judgment. Third, through information technologies and a sense of understanding, a leader must possess the mental acuity, creativity, and vision to develop and implement a sound decision.

As this monograph discussed, individuals tend to group perceptions, thoughts, or concepts into patterns. Mnemonic devices aid memory either through triggering a heuristic or assisting in recall of larger patterns through a system known as a mental model. What appears at first to be a catchy slogan, such as “Be All You Can Be” or “Be, Know, Do” may have a more developed meaning than the words initially indicate. These phrases become a recruiting mantra or a leadership vision for the Army. Memory devices, such as acronyms, train the mind to think or enable a complex thought to be understood and recalled. The skills listed in the previous paragraph were specifically grouped into three skill sets. For the purpose of this monograph, these three complex skill sets fall under the categorical slogans of achieving situational understanding, cybernetic mastery, and developing electronic *coup d'oeil*.

Situational Understanding. Situational understanding is the intuitive grasp of the entire battlefield. It is the simultaneous comprehension of all aspects, effects, and linkages, from knowing the morale and disposition of your soldiers, to the tactics and objective of the enemy, to the capabilities and effects of every weapon system. A competent leader may achieve situational awareness through a hierarchical analysis from a chosen perspective. This system may assist in problem solving, but not problem identification and understanding battlefield relationships. A proficient leader is deeply involved in gaining situational understanding, intuitively responding to patterns but still thinking analytically about what to do. However, an expert arrives rapidly at situational understanding through the application of experience and intuition from multiple perspectives. An expert understands the problem, identifies the constants and the variables, and determines the relationships between each. This section defines situational understanding and then addresses the necessary patterns involved in achieving situational understanding in terms of time, effects, intents, and functional relationships.

Situational understanding is “the knowledge of physical forces on the battlefield in relation to the nature, scope, and tempo of the operation. It includes the ability to identify patterns and relationships, to understand the critical points in time and space, and to recognize opportunities for decisive action.”¹²¹ Leaders “must assimilate thousands of bits of information to visualize the battlefield, assess the situation, and direct the military action required to achieve victory. These simultaneous characteristics of thinking and acting are those of expert decision making.

Given this complex mental process of achieving situational understanding, does the same information need to move through all levels of command to achieve situational understanding? Expertise is a function of knowing the right time to ask the right question. Is the answer always a “situationally dependent” default, or are there enough identifiable patterns to make rules and teach processes different from current ones, many of which were invented during the early part of this century and have served us all well in organizing information and problem solving?¹²² One could dismiss the notion of a possible solution set, in that each individual develops a different thought process or certain lower level leaders could not have the experience to develop situational understanding. However, the body of educational research would indicate that a disciplined program of education in college or professional graduate schools develops a system of thought that lasts a lifetime.

The essential element of situational understanding is time. Primarily, the decision maker must realize and assess the need for a decision before the optimal point or the opportunity to decide passes. Given that a leader develops a decision based on information and assumptions from a specific situation and set of conditions, there exists a finite time before that situation and those conditions change and the decision may not be valid, logical, or feasible. Deciding and acting before the situation or conditions change requires the application of creative thought and the ability to exercise initiative. But temporal concerns also include anticipating the time required to move a task force over broken ground at night, the time to shift artillery fire given their battalion’s training, or the time one has before the morale of a unit fails. Understanding these variables will influence recognition of the possible decisions and the optimal decision point in time.

The practice of command in battle has always been more art than science, demanding the creativity and initiative of expert decision makers. Initiative, like courage, may have two components -- physical and intellectual. The intellectual component of initiative may be the development of a battle rhythm between the commander and the staff. Battle rhythm is particularly linked to the intellectual initiative as it forces planning and decisions under uncertainty using predictive intelligence. As demonstrated with the discussion of Colonel Boyd's OODA Loop, these timely decisions allow for proactive rather than reactive combat. "The result is the aggressive execution of flexible plans and a confused enemy whose next step has been anticipated and disrupted."¹²³

A leader of character will have strong leadership skills that include both the intellectual and human components.¹²⁴ General Franks commented that during Operation Desert Storm his thoughts were on deciding to decide, which is a quality of expert decision making ability.¹²⁵ General Franks, noting the time, distance, and planning factors that go into executing a decision realized that as a senior commander, you really only get to make a few key decisions in the course of a battle or even a campaign. Therefore, a leader must anticipate when those decisions will happen, and not worry about decisions that should be made by subordinates.¹²⁶

An expert decision maker understands the effects and relationships of all factors on the battlefield. For example, a part of situational understanding is visualizing a covered and concealed route through a map reconnaissance, mentally creating the line of sight intervisibility lines. It is also seeing how that same terrain and those same routes may constrict movement, breakup an attack, limit the application of firepower, or be the enemy's most likely line of defense or attack. Through structured study, practice, and experience, an expert intuitively recognizes the patterns of information and may then inductively determine the relationships and effects of an unknown future state.

Achieving situational understanding in the information age includes appreciating function and intent. Comprehending function and intent may be viewed as a combination of analysis and synthesis. One must understand the individual elements and the relationships between elements to grasp the concept of function. However, full understanding entails more than a mastery of the primary relationships. Leaders must be cognizant of the second and third order consequences of ill-defined problems to

appreciate the complexities of function and intent. The ability to understand intent includes exercising sound judgment that recognizes the underlying assumptions behind decisions and the knowledge to identify quickly essential elements of information.

Understanding function and intent represent deep, versatile and agile thought developed through creative, repetitious and disciplined educational experiences. A leader develops an expert sense of situational understanding through a continuous mental struggle, breaking old mental models and developing new ones. Technology may assist in presenting many different opportunities to think, but cannot replace the mental effort of thought. Situational understanding develops more effectively and completely through a mentored dialogue, or the Socratic Method, where the emphasis is on the process of thought, not the contents of the thoughts themselves.

Cybernetic Mastery: The Human – Electronic Interface. Decision makers must develop the skill to take advantage of Force XXI technologies to first achieve, then optimize, their situational understanding in order to exercise battle command. The ability to recognize and change existing fears and expectations through versatile thought maximizes the advances in the area of information technologies. Military decision makers must possess the mental agility to link the information horizontally and vertically into meaningful patterns and functions. Individuals must understand the capabilities of technology and integrate that concept with human judgment. An ability of expert decision makers is knowing what you do not know and directing your efforts to determine the information requirements to identify and solve ill-defined problems. Digitization and automation are only effective tools when they either free the decision maker from routine tasks or allow the individual to focus on an essential decision. As such, this section first addresses cybernetics as primarily the study of the human-machine interface, then as the application of information age technologies within the function of decision making.

With the emphasis on information age technologies, our lexicon developed many new words using “cyber” as a prefix. For example, Dr. James J. Schneider, Professor of Military Theory at the United States Army School of Advanced Military Studies, discussed a concept of cybershock or cybernetic paralysis. In his presentation, cybershock means achieving the disruption or destruction of a military’s

complex nervous system, its ability to command, control, and function as a collective fighting entity.¹²⁷ However, for the purpose of this monograph, cybernetics specifically entails only the human control functions that information age systems are designed to augment or replace.¹²⁸ Cybernetic mastery means developing the skill set necessary in Force XXI operations to achieve expert performance in the functions of control.

War is inherently irrational, complex and uncertain – and all military decisions are made in this environment. Wars are not rational or logical because of the affective moral domain of human beings.¹²⁹ Wars may be fought with different or opposing intentions or purposes which, if not understood, could lead to poor decision making.¹³⁰ Irrelevant and inaccurate data can also increase the fog of war and further complicate the decision making process. From Alexander the Great to Napoleon, great military leaders would not hesitate to consult anyone who possessed expert knowledge if it would reduce the uncertainty of battle.¹³¹ Van Creveld called such insight a directed telescope and noted that commanders and staff could leverage technology to rapidly receive accurate information and direct subordinates to act.¹³²

Digitization of the battlefield and achieving information dominance are the main components for directed telescope of Force XXI. However, as Martin van Creveld said in the opening of *Command in War*, “The functions of command are eternal, but the means of command are constantly subject to evolution (organizations, procedures, and technical means.”¹³³ Although “the information processing capacity of computers in command centers has grown exponentially, the perceived processing load has grown by a larger exponent.”¹³⁴ Decision makers at all levels must remain cognizant that too much information may also provide for a military failure. The ability to conceptualize and communicate knowledge and understanding is essential to battle command. No single technological leap will answer all the complexities and uncertainties of command. The relevance of cybernetic mastery lies in the functional integration of digital technology and human ideas, emotions and will into expert decision making throughout the planning, preparation, and execution processes.

Electronic Coup D'oeil. Through information technologies and a sense of understanding, a leader must possess the mental acuity, creativity, and depth of thought to envision rapidly not only the entire environment, but also to develop and implement a sound decision. Throughout the centuries of conflict, many men understood the importance of knowledge in the exercise of military decision making. Perhaps the most recognizable bullet quotation attributed to Sun Tzu relates to the leader's responsibility to, "Know the enemy and know yourself."¹³⁵ Obvious to this end is a grasp of the composition, disposition and relationship of friendly and enemy forces. Sun Tzu's definition of "know" expands to also include a complete understanding of the effects of terrain, the tactical and strategic doctrine, when and where to fight, security, and nature of fighting deep. It would logically follow that if knowledge is the key to victory, then denying the enemy that ability, or deception, would be the basis for all military actions.¹³⁶ The leader must think, but to think one must first know.

In his classic treatise *On War*, Carl von Clausewitz intended to write on the development of understanding and preparedness of the military mind.¹³⁷ Although he systematically presented his theories and the titles or topic sentences may appear to be axioms, principles, or "bumper stickers," his book was about developing thought and a thought process.¹³⁸ This process of training and education admits great leaders may be born, but more importantly can be made.

Baron Antoine Jomini's *Art of War* discussed the importance of tactics, terrain, logistics, combined arms, courage, policy, and strategy.¹³⁹ However, Jomini's lasting contribution is not that the general should have a systematic technical knowledge, but rather the ability to know when to do what first. That recognized ability and insight of the great captains, *coup d'oeil*,¹⁴⁰ as Frederick wrote, was of the tactical thought process, not an application of approved solutions.¹⁴¹ Clausewitz expanded the concept of *coup d'oeil* as the genius to deal with the uncertainties of war and the strategic inward eye.¹⁴²

Jomini held that, "The greatest talent of a general and surest hope of success lie in some degree in the good choice of these points."¹⁴³ For generations, military leaders determined decisive points, dealt with the fog and friction of battle, and knew the limitations of war through their direct presence on the battlefield and the aggregate intelligence gathered from all available sources.

As the physical scope of war increased in terms of mass armies and dispersion, commanders could no longer see the entire battlefield and developed alternate means to gain the requisite information to make a decision. Martin van Creveld, in *Command in War*, describes the efforts of Marshal Berthier and Napoleon's General Staff, as a directed telescope, which the commander could use at will to gain information on his own units, the enemy, or the terrain tailored to meet his momentary and specific needs.¹⁴⁴ During the past two centuries, military leaders employed various technological advances to assist in the command of forces. For example decision makers used the telegraph, radio, helicopter, computer, and satellite to achieve situational understanding.

If the helicopter tended to exaggerate two of the fundamental traits of the American national character, impatience and aggressiveness,¹⁴⁵ what does it say about computer driven information technologies? "Designed to produce accuracy and certainty, the pressure exercised from the top for more and more quantitative information ended up by producing inaccuracy and uncertainty."¹⁴⁶ Computer generated decisions require that programmers anticipate all possible contingencies and rules for responses. Therefore, a computer alone operates in the realm of a competent decision maker, albeit a very fast, accurate and highly defined level of competency. However, the computer cannot replicate and thus forfeits the human expert's intuition. In a crisis or in combat, competence has never been good enough.¹⁴⁷

Expert decision makers may now employ the technologies of Force XXI to develop a sense of electronic *coup d'oeil*. Cybernetic mastery will assist in expert decision making by expanding stored memory, automating routine reports or tasks, or increasing the speed at which information travels. However, the uncertainties and complexities of warfare ensure that expert military decision making remains an intensely human activity of assumptions, judgments, and risks. Electronic *coup d'oeil* may appear as a slogan, but is meant to represent a radically faster battle command skill. Decision makers develop this skill set through the abilities and skills necessary to visualize and understand the entire area of operations, all the involved forces, and ever interrelated functions of the system. Electronic *coup d'oeil* is thus the complex skill set that integrates the concepts of knowing yourself, your enemy, and the effects of terrain with the advantages of information age technologies into an instantaneous and complete visualization of an event from multiple perspectives. Napoleon developed a sense of *coup d'oeil*, the

ability to visualize the entire battle in an instant, through intuitive study, practice, and experience.

Situational understanding and cybernetic mastery will only improve decision making skills if the decision maker can recognize patterns, understand system linkages and functions, and appreciate the effects of time. Force XXI leaders must develop a sense of electronic *coup d'oeil* to develop into expert decision makers in the information age.

The premise of Colonel Boyd's OODA Loop, and maneuver warfare theorists in general, is the ability to make and communicate decisions faster than the enemy is the primary means to create an environment in which the enemy cannot fight effectively. Currently, a "commander and staff may have seven hours or more to develop and communicate a deliberate plan before the enemy seizes the initiative, a future equivalent situation may allow less than 1 hour before facing an even graver event."¹⁴⁸ If Klein's argument for a leader's reliance on intuitive decision making remains true, there will be even less analytical decision making in future situations. Leaders may have access to more relevant information than ever before, but time is the limiting factor in future decision making. Decision makers must develop a sense of electronic *coup d'oeil*, the mental acuity to quickly achieve complete situational understanding for the purposes of battle command, through the repetitious use of information age technologies. Electronic *coup d'oeil* is the skill set of intellectual abilities to identify and solve problems as experts intuitively, not deductively, by recognizing the situation on the basis of experience and not science.

The conditions of Force XXI operations require leaders to possess the skill sets of situational understanding, cybernetic mastery, and electronic *coup d'oeil*. The supporting skills of mental acuity and agility, depth and versatility of thought, visualization, anticipation, imagination, creativity, and expert decision making are the essential to the development of these skill sets. Developing proficiency and expertise requires disciplined, structured experiences and the long-term commitment of the leaders as students and as teachers.

Chapter V. Recommendations

Science and history are opposing factors in the problem of the future means and methods of war. Anyone who seeks to solve the problem thoughtfully, instead of sensationally, soon feels their contradictory pull upon his mind. -- BH Liddell Hart

Given this discussion of the individual intellectual thought process, learning and development theory, expert decision making and the skills required users of the information technology systems, one may conclude that leaders will develop the situational understanding and visualization to enhance battlefield decision making capabilities in Force XXI mechanized battalions and brigades. However, the depth and extent of this affirmative answer lies within the context of a discussion on military education and training. The military education system should develop the abilities, skills, and skill sets that instill a thought process. Depth, and versatility of thought and mental acuity and agility arrive from a program that emphasizes inductive reasoning, creative thought, and complex problem solving. The military training system may develop expertise, initiative, and speed in decision making. Anticipation, imagination, agility and speed of thought mature through repetitious, realistic training across the entire spectrum of conflict. Education and training together develop the necessary skills and skill sets for Force XXI leaders.

Education. As the above quote from B.H. Liddell Hart implies, this is not an easy problem to solve and will require a great deal of forethought and planning. Higher level, professional education entails imparting instruction that facilitates student mastery of domain specific knowledge and abilities, but also the foundation, direction, and skills to solve complex, ill-defined problems.¹⁴⁹ With respect to both learning and intellectual development, however, the evidence is convincing that certain kinds of students benefit more from certain kinds of instructional approaches than they do from others. These advantages are especially apparent with instructional approaches that rely on small, modularized content units, require a student to master one instructional unit before proceeding to the next, and elicit active student involvement in the learning process.¹⁵⁰ The Army wide movement to small group instruction for most all centralized educational programs in the past decade reflects this observation. The United States Army has a multi-disciplined, career long developmental system that is combination of military schooling and individual development programs that include both formal and informal mentorship.

The Army affected a series of changes in its military school system instructional philosophy over the past decade that includes smaller classes, discussions, and video and computer based instruction. The body of evidence also demonstrates substantial advantages over traditional teaching formats have been

shown to be associated with a variety of individualized approaches, particularly the personalized system of instruction. The Keller Plan, which involves (among other things) having more-advanced students assume helping roles when other students have difficulties with course material, is embedded in the military ethos from basic training.¹⁵¹ The movement away from academic competition to cooperation enhances soldiers teaching soldiers, which then leads to development programs within staffs, squads, and other small units.

Educational research also indicates that instruction stressing inductive learning based on concrete activities appears with some consistency to promote gains in abstract reasoning and cognitive complexity.¹⁵² Inductive reasoning is a logical process in which an individual reaches a conclusion that contains more information than the observation or experience on which it is based, what may be considered “outside the box thinking.” Inductive reasoning is a critical skill that facilitates visualization, anticipation, and imagination. Deductive thought skills are important and necessary within a complex organization. However deductive skills focus solely on the facts and premises within the problem set. If the military is truly to develop proficient or expert initiative oriented thinkers, the learning model practiced within the formalized school system at all levels beyond the basic should change from deductive based thinking to the inductive based.

Remote and distance learning may be more cost effective, but is not as educationally effective as other techniques. The Armor and Military Intelligence Schools developed digitized support packages and offer extensive on-line support for training programs. General Montgomery C. Meigs, former commander of Combined Arms Center, developed the concept of the “University After Next,” complete with a virtual library and automated resources.¹⁵³ The question for the military is what is good enough? Visual-based Instruction (VI) consists of mainly films, slides tapes, and other video technology. Although favored by the students over conventional instruction, VI does not help attitude toward the subject matter material. The unsupervised execution of computer exercise will not achieve cybernetic mastery because there is no critical evaluation of and challenge to a thought process. Visual-based Instruction also shows no significant increase in academic performance over conventional methods.¹⁵⁴

If the educational intent is to share information and expand the available resource base, we should continue to develop computer assisted learning programs. However, if the goal is to develop initiative and

creative thought, we need to develop a more inter-active, thought provoking exchange. Examples include an electronic chat room or web-based bulletin board that offers free, but mentored dialogue. With respect to the quantitative advantages of computer generated information, one should not confuse the mental activity of creativity with the commodity oriented concept of productivity.

An option for improving the education process to meet the challenges of a Force XXI environment is to invest in the development of the facilitators. There are many dedicated, developed, and disciplined instructors in the school system. But there are also instructors at the service schools who are weak in terms of quality and expertise as teachers, and in some cases as military professionals.¹⁵⁵ As a simple consequence of motivation, if the members of the profession view an instructor position as meaningful and reward excellent performance, more members will pursue positions in the school system. If the Army chooses instructors from a centralized board process and develops each one through advanced civil schooling, the quality of instructors will increase. As the quality of facilitators increases, the military's attitude towards education should also improve. Understandably, the cost of upgrading the faculty is significant. However as the military prepares for the requirements of Force XXI, the institution cannot afford to focus on filling minds with information without developing a proper compass to use that information.¹⁵⁶

Most military schools use small group instruction and the adult learning model. Each school has a unique blend of senior and junior military officers as well as civilian professors who compose the faculty. However, because of a lack of instructor knowledge and ability in the art of teaching, many classes still focus on the procedural matters and rely heavily on the lecture format. Some instructors rely on view-graphs and discussions of historical examples and do not focus on the learning process or objectives. Instructors use these techniques not because of curriculum design, but rather because they rely on what they know. Faculty should develop expertise by doing, through practice – truly develop the skills required of a military artist.

Creativity and critical thought require a directed effort and time to develop. John Adair's work, *Training for Decisions*, addressed the dimensions of developing creative thought citing the work of Edward de Bono. Bono introduced a concept of lateral thinking to capture the spirit of creative thought. The

human mind does not necessarily think sequentially. Bono posited that vertical thought is akin to digging a hole deeper. Lateral thought is, “realizing that you cannot dig a hole in a different hole in a different place by digging the same hole deeper.”¹⁵⁷ In other words, the same solution does not always apply and lateral thinking will enable the mind to view the problem from another perspective. Adair’s conclusion was similar to Martin van Creveld’s in *The Training of Officers* and Frederic Brown’s *The U.S. Army in Transition II*. Intense leader training begins with high quality instructors who first challenge conventional the thought processes, then focus on the rapid assimilation and synthesis of new information to achieve expertise.¹⁵⁸

Given a reliance on initiative oriented skills and skill sets, military doctrine, training, and experience become more important as all leaders search for creative solutions to complex problems in a decentralized environment. Brigadier General (Retired) Huba Wass de Czege, stated that most of the commander’s ability to make decisions, lead, and motivate subordinates, “is inherently intellectual because people must transform data into information, then knowledge - - and they must do it quickly.”¹⁵⁹ It takes and effort time to develop a disciplined thought process, the expertise to solve complex, ill-defined problems, and the ability to execute solutions. General Wass de Czege added that, “mental acuity and the intellectual component of battle command will become critical as our future Army increasingly depends on the benefits of knowledge.”¹⁶⁰

A successful developmental program that fosters inductive reasoning and initiative must involve everyone. Classroom activities that require student participation, topical discussions, assignments that call upon higher-order thinking, problem-solving activities, in-class presentations, and student involvement in decisions about course content and activities appear to promote course involvement.¹⁶¹ The synergistic effect of students thinking collectively and solving complex problems through a mentor led dialogue may be seen as the basis for the adult learning model. This concept of education stands in contrast to any misperceptions that the adult learning model is a solitary effort in reading, lectures, and discovery learning to achieve subject matter competency.

The same philosophy of training used in unit level tactical exercises should be used in the school environment. One could develop a series of original exercises designed to prepare the leadership to

anticipate, manage, and exploit change. Institutions develop exercises specific to their training needs, be they tactical, operational, strategic, or logistic in nature. This could be done by situational exercises that lack definition and change in mid-course.¹⁶² Once a student solves a problem, give it again with minor changes and only accept a different solution. Computer generated simulations allow many iterations of leadership training exercises to occur at relatively low costs. The generation of multiple activities will assist in developing expertise in problem identification and decision making. However, the challenge for the military remains to provide mentored observation of as many different patterns and scenarios as possible.

The current wave of digitization will not ebb any time in the foreseeable future. The Advanced Warfighting Experiment evidenced that the digitized command and control systems architecture, could enhance simultaneous planning and execution if the staffs achieved greater proficiency.¹⁶³ The military should continue to improve technical literacy and expertise in the field of computers, not only in terms simple mastery of new equipment, but greater understanding of what a system does and does not do. Once the commander understands the information and the parameters, then it is of use in the visualization and decision making process. There are many contractors searching for innovative approaches to the use of technology based training and administration. However, leaders must always be able to maximize the efficiencies and capabilities of digitized information to enhance, not inhibit decision making.

The changes in education are not only required for the experimental forces of the AWE. The dynamic complexities of a changing world require a change in thought process as our models have all changed. The technologies available to all military forces can greatly enhance situational understanding and battle command if used properly. One may change thought through changing doctrine, instructional lesson plans, techniques, tactics, and procedures.

One example of such change is provided by Colonel John D. Rosenberger's article, "Training Battle Command: Coaching the Art of Battle Command." Colonel Rosenberger focused on the use of the Socratic Method of a dialogue to developing thought and individual cognitive abilities. Although being able to see the terrain, see the enemy, see yourself, and envision the battle is the essence of battle command, the leadership skills necessary to develop thought in others through challenging perspectives,

patterns and assumptions is equally as important.¹⁶⁴ In this instance of developing battle command, one can see that distance learning is only a supplement to personalized mentors and dialogues.

Training. The human mind will remain the critical dimension on the battlefield, so our next question is how do we train it? Training is a series of related events designed to develop habits of thought and behavior through instruction and practice.¹⁶⁵ Training the mind to adapt to information age technology must be a matter of developing competency, proficiency, and then expertise, without chaining the commanders or the staff to command posts and video monitors. As discussed in the learning process and education, one should remember the importance of analysis and synthesis -- the dialectic process of transforming data into understanding; information into knowledge. Repetitious, realistic training will develop initiative, expert decision making, anticipation, and imagination.

One may develop expert knowledge through repetitious training in realistic situations across the entire spectrum of conflict. Training simulations provide leaders with opportunities to exercise decision making skills and then reflect on their thought processes. These simulations include constructive (computerized wargames that model units and focus on command and staff functions), virtual (integrated machines that focus on smaller units, staffs, and crews), and live exercises (such as those conducted at local installations or the National Training Center). The Battle Command Training Program supports the training of higher echelon commanders and staffs through the application of complex problems, under the pressure of time constraints, and, most importantly, with an external, mentored evaluation of the individuals. The training of Force XXI leaders must present decision makers with as many situations and variables as possible to force decisions again and again – this takes time and practice. Second, a skilled mentor should conduct a dialogue with the individual to determine the thought processes used and ways to improve. The leader develops the abilities and skills to form new patterns, linkages, and predictions based on the experiences.

Over time, the military as a collective body will develop new patterns and models that will fundamentally change the intuitive and analytical manner it perceives itself and the environment. Changes to a new doctrine are not universally accepted and practiced overnight. It requires a substantial investment

of time and resources to change a mindset. Leaders in Force XXI conditions can no longer look towards General Starry's AirLand Battle concept of a deep, close, and rear configuration of the battlespace. The ill-defined nature of our future environment requires a depth of thought to appreciate second and third order consequences, anticipate to develop predictions, and quickly decide. Whether one defines the new framework by time (current-future), function (engagement-sustainment), physical space (depth and simultaneous) or something entirely different, the important matter is to recognize the need for change.

Initiative oriented warfighting centers on the commander's intent and the subordinate's ability to understand, think, and execute. Results from last year's DAWE found a weakness in the ability to anticipate information requirements and communicate them to focus the intelligence and targeting efforts.¹⁶⁶ Information age technologies enable intelligence systems to acquire virtually limitless information about the enemy, the terrain, and friendly forces. Therefore, commanders must develop meaningful intelligence requirements that contribute to their decision making. A directed telescope should not be a fire hose, filling the command post with useless data. Leaders have many different ways to solve problems, and the ability to discover unique, creative solutions has always been a strength of the US Army.

The military must recognize the reduced planning horizons of future situations. A leader may only have an hour or less to make the one decision that really matters. This is a mental agility to solve complex problems quickly in order to control the tempo through seizing the initiative. The future will not stand still and wait for anyone. Our military must develop the ability to command on the move. Power projection implies a rapid movement to a foreign area of operation. There will be very limited time before the decision may be obsolete.

This chapter addressed the necessity to address changes in the military education and training systems to develop and instill a thought process. The systems are in place to develop leaders with the abilities and skills required in the operational conditions of Force XXI. Information technologies and simulations serve only to enhance decision making capabilities, not supplant them. Depth, agility and versatility of thought arrive from a program that emphasizes inductive reasoning, creative thought, and complex problem solving. Expertise, initiative, and decision making skills evolve through repetitive, realistic training across the entire spectrum of conflict.

Chapter VI. Conclusion

Man is the fundamental instrument in battle. -- Ardant du Picq

The users of the information technology systems will develop the situational understanding and visualization to enhance the battlefield decision making capabilities in the Force XXI mechanized battalions and brigades. However, the organizational transition to Force XXI will be neither easy nor fast. Changing organizational systems and patterns of thought takes time, patience, encouragement, and planning. Whether one thinks of the current times as an evolution or revolution in military affairs, one cannot deny we are in the midst of a paradigm shift from the industrial age to the information age. The significant change of information age warfare is the rapid, decentralized flow of information. The essential requirement is to develop commanders and staffs that possess expert decision making skills to turn the information made possible through digitization into situational understanding and action.

One fosters this intellectual development through training and educational experiences that challenge existing thought structures and mental models. The challenge is to embed an educational, training, and command philosophy, such as electronic *coup d'oeil*, that develops a new mindset to harness the technological advantages of the information age. This monograph recommended a new way of conceptualizing the battlefield, a different approach of formalized instruction, and a fundamental change in the process of developing subordinate leadership skills. The ability to exercise battle command of non-linear, distributed operations over an expanded area requires leaders who possess expert decision making skills, acute situational understanding, and the initiative to act upon their decisions. Through the disciplined education of, and training with, information age technologies, leaders of Force XXI organizations will be able to see the forest for the trees.

Endnotes

¹ Department of the Army, Headquarters, Training and Doctrine Command, TRADOC Pamphlet 525-5, *Force XXI Operations – A Concept for the Evolution of Full-Dimensional Operations* (Fort Monroe, Virginia: 1 August 1994), 1-1.

² For the purposes of this paper, digitization is the process of applying information age technology to transform command, control, communications, and intelligence information into computerized, digital data.

³ Antulio Echevarria, "Dynamic Inter-Dimensionality: A Revolution in Military Theory," *Joint Force Quarterly*, 15 (Spring 1997), 29-36.

⁴ Department of the Army, Headquarters, Training and Doctrine Command, TRADOC PAM 525-5, *Force XXI Operations – A Concept for the Evolution of Full-Dimensional Operations* (Fort Monroe, Virginia: 1 August 1994), Glossary-1.

⁵ Department of the Army, Headquarters, FM 100-5, (DRAFT), *Operations* (Fort Leavenworth, Kansas: June 1998), 2-14. Department of the Army, Headquarters, Training and Doctrine Command, TRADOC Pamphlet 525-70, *Battlefield Visualization Concept* (Fort Monroe, VA: 1 October 1995).

⁶ Department of the Army, Headquarters, Field Manual 100-5, (DRAFT), *Operations* (Fort Leavenworth, Kansas: June 1998), 2-14.

⁷ Department of the Army, Training and Doctrine Command, Center For Army Lessons Learned, *Advanced Warfighting Experiment, NTC Rotation 97-06* (Fort Leavenworth, Kansas: March 1997), Annex A, 1-4 and Annex B, 1-5. Available also at <http://www.ado.army.mil/docs/sasc/annexa/annexa.html> and <http://www.ado.army.mil/docs/sasc/annexb/annexb.html>; Internet.

⁸ Department of the Army, Training and Doctrine Command, Center For Army Lessons Learned, *Division XXI Advanced Warfighting Experiment (DAWE), Initial Insights Report (IIR)*, "Demonstrated Challenges to Battle Command" (Fort Leavenworth, Kansas: 21 January 1998), 28.

⁹ *Ibid.*, 28.

¹⁰ Department of the Army, Battle Command Battle Lab, Pamphlet, 2-1, *Focused Rotation Findings* (Fort Leavenworth, KS: 1996), 1-5. The four basic questions were specifically: Where am I? Where is the enemy? Where are my units? What is everyone doing?

¹¹ *Ibid.*, 1-5.

¹² Dennis K. Leedom, and Jon Fallesen, "Initial Insights From Prairie Warrior 98: Cognitive Engineering of the Digital Battlefield" (Army Research Laboratory, Fort Leavenworth, Kansas: 3 September 1998), 1-4. Department of the Army, Training and Doctrine Command, Center For Army Lessons Learned, *Advanced Warfighting Experiment, NTC Rotation 97-06*, (Fort Leavenworth, Kansas: March 1997).

¹³ Department of the Army, Headquarters, Field Manual 100-5, (DRAFT), *Operations* (Fort Leavenworth, Kansas: June 1998), 3-3. "Enhanced communications abilities and technologies allow the creation of a common operational picture, which is the near simultaneous sharing of the operational

picture. This common data operational picture means something to everyone who looks at it. The set of human perceptions extrapolated from the operational picture results in situational awareness."

¹⁴ General Johnnie E. Wilson, "The Information Age Army," *Army Magazine*, 47(6), (June 1997), 17-18. General Johnnie E. Wilson, Commanding General of the U.S. Army Material Command, described achieving situational awareness as when "soldiers on the battlefield can locate the enemy rapidly, coordinate firepower accurately, and destroy positions effectively while reducing the chances of fratricide." William H. Campbell, "NTC to Test Digitization," *Army Magazine*, 44(2), (February 1994), 34. Major General William H. Campbell, the program executive officer for command and control systems, wrote that "lower levels need situational awareness to display a common picture of the battlefield showing where you are, where your teams are and where the enemy is -- information that is updated as changes occur."

¹⁵ Department of Defense, Office of the Assistant Secretary of the Army (Research, Development, and Acquisition), *Weapons Systems 1998* (Washington, D.C.: U.S. Government Printing Office, 1998), 2-5, 13, 49, 122-123. Gerry J. Gilmore, "Land Warrior: Soldier of the Future," Available at the Department of the Army Home Page, <http://www.dtic.mil/armylink/news/Feb1997/r19970214pressadv.html>; Internet

¹⁶ William S. Lind, *Maneuver Warfare Handbook* (Boulder: Westview Press, 1985), 5-8.

¹⁷ Joint Chiefs of Staff, OC Incorporated, software developers, *Joint Electronic Library*, CD-ROM (Washington D.C.: U.S. Government Printing Office, 1998), "JEL Encyclopedia," 222-225.

¹⁸ Herbert S. Kindler, *Risk Taking: A Guide for Decision Makers* (Menlo Park, CA: Crisp Publications, 1990), 39. The graph is not mathematical in nature, merely visual. Whether or not the cost relationship is true exponential is not relevant to the intuitive fact that it becomes much more difficult or costly to determine that last bit of information or data in a complex environment.

¹⁹ Chester F. Dymek, III, "Intellectual Development" (Masters Thesis, Long Island University and United States Military Academy, West Point, New York, 1994), 2-3.

²⁰ Ernest T. Pascarella and Patrick T. Terenzini, *How College Affects Students: Findings and Insights from Twenty Years of Research* (Jossey Bass: San Francisco, CA, 1991). William Crain, *Theories of Development: Concepts and Applications* (Englewood Cliffs, NJ: Prentice Hall, 1992). Robert G. Kegan, "The Evolving Self: A Process conception for Ego Psychology," *The Counseling Psychologist*, 8(2), (1979), 5-34. William G. Perry, Jr., *Forms of Intellectual and Ethical Development In the College Years: A Scheme* (Fort Worth, Texas: Harcourt, Brace Jovanovich College Publishers, 1968).

²¹ Albert Bandura, *Social Learning Theory* (Englewood Cliffs, NJ: Prentice-Hall, Incorporated, 1977), 11-12.

²² Raymond J. Corsini and Danny Wedding *Current Psychotherapies, Fourth Edition* (Itasca, IL: F.E. Peacock Publishers, 1989), 538.

²³ Ibid., 538.

²⁴ Ibid., 517.

²⁵ Plato, *The Republic*, Desmond Lee, trans. (New York: The Viking Penguin Press, 1979). Immanuel Kant, *Immanuel Kant's Critique of Pure Reason*, Norman Kemp Smith, trans. (New York: St. Martin's Press, 1969). Richard L. Gregory, ed., *The Oxford Companion to the Mind* (Oxford University Press, New York, 1987). Crain, 4, 75, 153, 156. *Compton's Interactive Encyclopedia, 1998 Version*, "Kant" (Cambridge, Massachusetts: The Learning Company, 1997).

²⁶ Gregory, 154, a discussion of "common sense." Crain, 196. *Compton's Interactive Encyclopedia, 1998 Version*, "Hegel."

²⁷ Crain, 222-270, 287-298.

²⁸ Crain, 100-133, 222-246. *Compton's Interactive Encyclopedia, 1998 Version*, "Piaget."

²⁹ Crain, 75-99.

³⁰ Arthur W. Chickering, *Education and Identity* (San Francisco, CA: Jossey Bass, 1990).

³¹ Perry.

³² Michael D. Williams, James D. Hollan, and Albert L. Stevens, "Human Reasoning About a Simple Physical System," In *Mental Models*, eds. Dedre Gentner and Albert L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983), 131.

³³ Hillel J. Einhorn, "Learning from Experience and Suboptimal Rules in Decision Making," In *Cognitive Processes in Choice and Decision Behavior*, ed. Thomas S. Wallensten (Hillsdale, NJ: Lawrence Erlbaum Associates, 1980), 1-4.

³⁴ Barauch Fischhoff, Paul Slovic, and Sarah Lichtenstein. "Knowing What You Want: Measuring Labile Values. In *Cognitive Processes in Choice and Decision Behavior*, ed. Thomas S. Wallensten (Hillsdale, NJ: Lawrence Erlbaum Associates, 1980), 118.

³⁵ Ibid., 119.

³⁶ Ludwig von Bertalanffy, *General System Theory: Foundations, Development, Applications. Revised Edition* (New York: George Braziller, 1968).

³⁷ Einhorn, 2-9.

³⁸ Camille B. Wortman, Elizabeth F. Loftus, and Mary Marshall, *Psychology* (New York: Alfred A. Knopf, 1981), 551-554.

³⁹ Massimo Piatelli-Palmarini, *Inevitable Illusions: How Mistakes of Reason Rule Our Minds* (New York: John Wiley & Sons, 1994), 3.

⁴⁰ Ibid., 3-15.

⁴¹ Leonard Uhr, *Pattern Recognition, Learning, and Thought: Computer-Programmed Models of Higher Mental Processes* (Englewood Cliffs NJ: Prentice Hall, 1973), 18.

⁴² M. Bongard, *Pattern Recognition* (New York: Spartan Books, 1970), 1-9.

⁴³ Crain, 77-99.

⁴⁴ Johan de Kleer and John Seely Brown, "Assumptions and Ambiguities in Mechanistic Mental Models," In *Mental Models*, eds. Dedre Gentner and Albert L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983), 185.

⁴⁵ Ibid., 186.

⁴⁶ Peter M. Senge, *The Fifth Discipline: The Art & Practice of the Learning Organization* (New York: Doubleday, 1990), 8.

⁴⁷ Gentner and Stevens, 1-6.

⁴⁸ Senge. Chris Argyris, *Overcoming Organizational Defenses: Facilitating Organizational Learning* (Needham Heights, MA: Allyn and Bacon, 1990). Among others, Peter Senge's, *The Fifth Discipline* and Chris Argyris' *Overcoming Organizational Defenses*, both examine common logical fallacies and resistance to changing mental models from a systems perspective. According to Senge, the crucial skill for the individual to understand a complex system is to change recognize the patterns of thought and the mental model in use. Once an individual understands the processes involved in a dynamic complexity of interrelationships, one can develop a more effective mental model. Senge's argument runs concurrent to the Gestalt theory of examining whole systems, but Argyris examines the importance of each element within patterns of defense mechanisms.

⁴⁹ Williams, Hollan, and Stevens, 131-135.

⁵⁰ Richard M. Young, "Surrogates and Mapping: Two Kinds of Conceptual Models for Interactive Devices," In *Mental Models*, eds. Dedre Gentner and Albert L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983), 50.

⁵¹ Williams, Hollan, and Stevens, 134.

⁵² Donald A. Norman, "Some Observations on Mental Models," In *Mental Models*, eds. Dedre Gentner and Albert L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983), 12.

⁵³ Williams, Hollan, and Stevens, 135.

⁵⁴ Norman, 14.

⁵⁵ Ibid., 12-14.

⁵⁶ Dedre Gentner and Donald Gentner, "Flowing Waters or Teeming Crowds: Mental Models of Electricity," In *Mental Models*, eds. Dedre Gentner and Albert L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983), 118.

⁵⁷ Ibid., 124-125, 127.

⁵⁸ Norman, 7-8.

⁵⁹ When comparing Norman's six rules of thought to the main argument in Meritt Roe Smith and Leo Marx's work, *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, Massachusetts: The MIT Press, 1995), one could imagine the mind in terms of a "mental bureaucracy." I would define this mental bureaucracy as many pieces working towards a goal, but not always in unison or with all efforts centrally directed. Smith, a professor and director at MIT, and Marx, a senior lecturer and professor emeritus, described the unpredictabilities and complexities of technological and social changes which can be seen in our military's questions of interoperability, "work-arounds," communications, organizational redesign, and control. Some members of the military pride themselves in making a system work, taking initiative to solve a problem in a unique manner -- breaking governing rules of some mental models. These rules we establish to increase efficiency, that seem to work, even if they make no common sense.

⁶⁰ Williams, Hollan, and Stevens, 151.

⁶¹ *Random House College Dictionary, Revised Edition*, ed. Jess Stein (New York: Random House, 1980), 1232.

⁶² Dennis K. Leedom and Jon Fallesen, "Initial Insights From Prairie Warrior 98: Cognitive Engineering of the Digital Battlefield" (Fort Leavenworth, Kansas: U.S. Army Research Laboratory, 3 September 1998), 2, 4, 6.

⁶³ Rex Michel, "Measuring Battlefield Knowledge Structures: Test of a Protocol Analysis Approach" (Fort Leavenworth, Kansas: U.S. Army Research Institute for the Behavioral and Social Sciences, June 1998), 2. Dr. Michel summarized the work of the following publications: Glaser, 1984; Ceci and Ruiz, 1992; Royer, Cisero, and Carlo, 1993; Federico, 1995 in arriving at his assessment.

⁶⁴ Hubert L. Dreyfus and Stuart E. Dreyfus, *Mind Over Machine: The Power of Human Intuition and Expertise in the Era of the Computer* (New York: Macmillan, Inc., 1986), 19.

⁶⁵ *Ibid.*, 16-51.

⁶⁶ Michelene T.H. Chi, Robert Glaser and Marshall Farr, eds., *The Nature of Expertise* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), 36.

⁶⁷ Michel, 2. Dr. Michel summarized the work of the following publications: Wiser and Carey, 1983; Scribner, 1986; Lawrence, 1988; Johnson-Laird, 1989; Van Lehn, 1989 in determining his assessment.

⁶⁸ Chi, Glaser, and Farr, xv.

⁶⁹ *Ibid.*, xvii through xx. See Annex C, Decision Making Experimental Research Data and Summaries, for a complete listing of their observations for each of the seven findings.

⁷⁰ Andrea A. diSessa, "Phenomenology and the Evolution of Intuition," In *Mental Models*, eds. Dedre Gentner and Albert L. Stevens (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983), 32-3.

⁷¹ Elliot Soloway, Beth Adelson, and Kate Ehrlich, "Knowledge and Processes in the Comprehension of Computer Programs," In *The Nature of Expertise*, eds. Michelene T.H. Chi, Robert Glaser and Marshall Farr (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), 130.

⁷² Chi, Glaser, and Farr, xxxiv.

⁷³ *Ibid.*, xxxiv.

⁷⁴ James J. Straszewski, "Skilled Memory and Expert Mental Calculation," In *The Nature of Expertise*, eds. Michelene T.H. Chi, Robert Glaser and Marshall Farr (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), 76-77. Experts exploit long term memory to expand working memory capacity in terms of three principles of skilled memory:

(1) The mnemonic encoding principle (this principle states that experts encode new information in terms of an existing knowledge base, thus exploiting information in LTM as a mnemonic aid);

(2) The retrieval structure principle (this principle asserts that experts use their knowledge of a domain to develop abstract, highly specialized mechanisms for systematically encoding and retrieving meaningful patterns in LTM;

(3) The speed up principle (This principle states that practice increases the speed (and reliability) with which experts (a) recognize and encode meaningful patterns and (b) store and retrieve information

using retrieval structures). Also seen in Rex Michael's report, "To sum it up, it appears that expert mental calculators use semantic memory in three principal ways to achieve fast and accurate performance. First, consistent with skilled memory theory's mnemonic encoding principle, they use an elaborately interrelated knowledge base to recognize and encode meaningful patterns of numbers that occur either as problems or embedded sub-problems, thus promoting their retention. Second, much like chess-masters apparently use their pattern recognition capabilities to efficiently select chess moves, calculation experts use their unique pattern recognition capabilities to effectively select efficient computational strategies on a problem-by-problem basis. Finally, experts use their knowledge to replace computation with retrieval as a means of generating products and intermediate results, thereby decreasing solution times.

⁷⁵ Ibid., 81.

⁷⁶ Michael I. Posner, "What is it to be an expert?" In *The Nature of Expertise*, eds. Michelene T.H Chi, Robert Glaser and Marshall Farr (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), xxi.

⁷⁷ Eric J. Johnson, "Expertise and Decision under Uncertainty: Performance and Process," In *The Nature of Expertise*, eds. Michelene T.H Chi, Robert Glaser and Marshall Farr (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), 209, 212.

⁷⁸ Straszewski, 113. Michel, 2-3.

⁷⁹ Michel, 3.

⁸⁰ Straszewski, 104.

⁸¹ Michel, 3-5. Dr. Michel summarized the work of the following publications: Foley and Hart, 1992, Soloway, Adelson, and Ehrlich, 1988; Humphreys, et. al., 1990; Royer, Cirero and Carlo, 1993, in his assessment.

⁸² Michel, 4-5. Straszewski, Posner, and Dreyfus and Dreyfus among others expressed similar findings.

⁸³ Dreyfus and Dreyfus, 181.

⁸⁴ Ibid., 163.

⁸⁵ Herbert A. Simon, "Theories of Decision Making in Economics and Behavioral Science," *American Economic Review*, 49, (1959), 272.

⁸⁶ Chi and Glaser, xxv.

⁸⁷ James F. Voss and Timothy A. Post, "On the Solving of Ill-Structured Problems." In *The Nature of Expertise*, eds. Michelene T.H Chi, Robert Glaser and Marshall Farr (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), 261-284.

⁸⁸ Department of the Army, Headquarters, Field Manual 101-5, *Staff Organizations and Operations* (Washington, D.C.: June 1997). 5-1.

⁸⁹ Jeanette A. Lawrence, "Expertise on the Bench: Modeling Magistrates' Judicial Decision Making," In *The Nature of Expertise*, eds. Michelene T.H Chi, Robert Glaser and Marshall Farr (Hillsdale, NJ: Lawrence Erlbaum Associates, 1988), 229, 256-7.

⁹⁰ Chi and Glaser, xvi.

⁹¹ de Kleer and Brown, 182.

⁹² Dreyfus and Dreyfus, 101.

⁹³ Kevin Kelly, *Out of Control: The New Biology of Machines, Social Systems, and the Economic World* (Reading, MA: Addison-Wesley Publishing Company, 1994), he addresses the dimension of time in his chapters "Machines with an Attitude," 295-296, "Artificial Evolution," 283-311, and the "Structure of Organized Change," 352-364.

⁹⁴ Dreyfus and Dreyfus, "Given their rigor, reliability, and indefatigability, computers used as logic machines do extremely well what human beings do only poorly. Human beings, however, exhibit a flexibility, judgment, and intuition that resist decomposition into specification and inference and have proves equally difficult to instill into logic machines," 63.

⁹⁵ Ibid., "Another human skill that logic machines cannot simulate is the ability to recognize the similarity between whole images. Recognizing two patterns as similar, which seems to be a direct process for human beings, is very complicated for a logic machine," xi and 57.

⁹⁶ Dreyfus and Dreyfus, xxi. Hubert Dreyfus, *What Computers Still Can't Do* (Cambridge, MA: The MIT Press, 1992), 285.

⁹⁷ Dreyfus and Dreyfus, 80. Hubert Dreyfus, 256-271.

⁹⁸ Dreyfus and Dreyfus. 226.

⁹⁹ Ibid., 3.

¹⁰⁰ Rex V. Brown, "Normative Models for Capturing Tactical Intelligence Knowledge." In *Science of Command and Control: Coping with Complexity, Part II*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1989), 74.

¹⁰¹ Carl von Clausewitz, *On War*, trans. and ed. Michael Howard and Peter Paret (Princeton, New Jersey: Princeton University Press, 1984), 101.

¹⁰² Israel Mayk and Izhak Rubin, "Paradigms for Understanding C3, Anyone?" In *Science of Command and Control: Coping with Uncertainty*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1988), 52-7.

¹⁰³ Ibid., 52-7.

¹⁰⁴ David Noble and Ronald Mullen, "Information Presentations for Distributed Decision Making," In *Science of Command and Control: Coping with Uncertainty*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1988), 128.

¹⁰⁵ Herbert S. Kindler, *Risk Taking: A Guide for Decision Makers* (Menlo Park, CA: Crisp Publications, 1990).

¹⁰⁶ Harry L. Van Trees, "C3 Systems Research: A Decade of Progress," In *Science of Command and Control: Coping with Complexity, Part II*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1989), 36. Clausewitz, 75-89, 100-112.

¹⁰⁷ Gary A. Klein, "Naturalistic Models of C3 Decision Making," In *Science of Command and Control: Coping with Uncertainty*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1988), 86. He studied ways to elicit knowledge and apply data for training, decision support systems, and expert systems.

¹⁰⁸ Ibid., 86-7.

¹⁰⁹ Ibid., 87.

¹¹⁰ Ibid., 88. Klein cited the work of Howell, 1984; Zakay and Wooler, 1984; and Rouse, 1979.

¹¹¹ Brown, 69.

¹¹² Didier M. Perdu and Alexander H. Levis Perdu, "Evaluation of Expert Systems in Decision Making Organizations," In *Science of Command and Control: Coping with Complexity, Part II*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1989), 76.

¹¹³ Roy M. Gulik and Anne W. Martin, "Managing Uncertainty in Intelligence Data -- An Intelligence Imperative," In *Science of Command and Control: Coping with Uncertainty*, eds. Stuart E. Johnson and Alexander H. Levis (Washington, D.C.: National Defense University, AFCES International Press, 1988), 11.

¹¹⁴ Gregory A. Roman, *The Maxwell Papers*, "The Command or Control Dilemma: When Technology and Organizational Orientation Collide, Paper Number 8" (Maxwell AFB, AL: Air War College, 1997), 2.

¹¹⁵ Ibid., 3.

¹¹⁶ Ibid., 12.

¹¹⁷ van Creveld, 2, 3, 44, 268-275.

¹¹⁸ Corbin, 50-57. She details the classification of non-decisions, which still may decisions and need to be accounted for in a decision making model.

¹¹⁹ Ibid., 50-57.

¹²⁰ Department of the Army, Training and Doctrine Command, TRADOC Pamphlet 525-5, *Force XXI Operations - A Concept for the Evolution of Full-Dimensional Operations*, (Fort Monroe, VA: 1 August 1994), Chapters 1 and 3. Department of the Army, Training and Doctrine Command, TRADOC Pamphlet 525-66, *Future Operational Capability*, (Fort Monroe, VA 1 May 1997). Gordon Sullivan and Anthony M. Corrales, "The Army in the Information Age, Part 1 of 2," (SSI HomePage, U.S. Army War College, Carlisle Barracks, 31 March 1995), 3. Available from <http://carlisle-www.army.mil/ns-search/usassi/ssipubs/pubs95/armyinfo/sull-1-1.htm>; Internet.

¹²¹ Department of the Army, Headquarters, Field Manual 100-5, (DRAFT), *Operations* (Fort Leavenworth, Kansas: June 1998), 2-14.

¹²² General Frederick Franks, "Battle Command," *Military Review*, 76(3), (May-June 1996): 12.

¹²³ Major Robert F. Dees, "Battle Rhythm," *Military Review*, 67(4), (April 1987): 59-64.

¹²⁴ Franks, 15.

¹²⁵ Ibid., 16. Often the biggest choice is when to decide and when not to. An example of expert decision making could be as follows. "In making decisions during Desert Storm, I got maybe 20% of my information during battle from CP input, 50% from being up front on the battlefield and getting assessments from my commanders and 30% from embedded memory of education and training." Competence, knowing the terrain from walking it, knowing the enemy from studying and continued to assess, know the capabilities and limitations of your systems which will drive your tactics, communication skills, build a good team. "The brigade can fight no better than the brigade commander's ability to see the terrain and appreciate weather's effects, see the enemy, see himself, and see the battlefield unfold in his mind." "In other words, I had to ask myself, did I need to intervene, did I need to make a decision at that point or did I need to add reinforcements to help a subordinate unit accomplish the mission I gave them or give them time and reinforcements to exploit an initiative they created."

¹²⁶ Ibid., 18.

¹²⁷ Dr. James J. Schneider, "Cybershock: Cybernetic Paralysis as a New Form of Warfare" published in *Military Review* and "Black Lights: Chaos, Complexity and the Promise of Information Warfare," published in *Joint Force Quarterly*, 15, (Spring 1997). Both articles contained in *The Foundations of Military Theory Course Syllabus* (Fort Leavenworth, Kansas: USACGSC, School of Advanced Military Studies, 10 May 1998).

¹²⁸ Stein, 331.

¹²⁹ Clausewitz, 76. "Consequently, it would be an obvious fallacy to image war between civilized peoples as resulting merely from a rational act on the part of their governments and to conceive of war as gradually ridding itself of passion, so that in the end one would never really need to use the physical impact of fighting forces – comparative figures of their strength would be enough."

¹³⁰ B.H. Liddell Hart, *Strategy, Second Revised Edition* (New York: Meridian Books, Penguin Group, 1991). Edward N. Luttwak, *Strategy: The Logic of War and Peace* (Cambridge, Massachusetts: The Belknap Press of the Harvard University Press, 1987). Harry G. Summers, *On Strategy: A Critical Analysis of the Vietnam War* (Novato, California: Presidio Press, 1982).

¹³¹ John Keegan, *The Mask of Command* (New York: Penguin Books, 1987), 40-47 and 80-89. Discussing Alexander's use of surveyor's secretaries, clerks, doctor's, scientists, and a historian as advisor's. He was aggressive, invasive and risk taking, sometimes listening to one subordinate voice over all others or none at all. LTC Gary B. Griffin, "The Directed Telescope: A Traditional Element of Command" (Fort Leavenworth, Kansas: USACGSC, Combat Studies Institute, 1991), 1, 2, 35-38.

¹³² van Creveld, 75, 115, 246, 247, 252.

¹³³ Ibid., 9-10.

¹³⁴ Ibid., 39.

¹³⁵ Sun Tzu, *The Art of War*, In *Roots of Strategy, Volume I*, ed. T.R. Phillips (Harrisburg: Stackpole Books, 1985), 28.

¹³⁶ Ibid., 23, 34-36.

¹³⁷ Clausewitz, 579, "No one starts a war -- or rather, no one in his senses ought to do so -- without first being clear in his mind what he intends to achieve by war and how he intends to conduct it."

¹³⁸ Ibid., 70, "The fruit of years of reflection on war and the diligent study of it." "Theory should cast a steady light on all phenomena so that we can more easily recognize and eliminate the weeds that always spring from ignorance; it should show how one thing is related to another, and to keep the important and unimportant separate," 578.

¹³⁹ Antoine Jomini, *The Art of War*, In *The Roots of Strategy, Book 2*, ed. BG J.D. Hittle (Harrisburg, PA: Stackpole Books, 1987). Three definitions that are important to understanding Jomini's operational construction of the battle field are strategy, tactics, and logistics. "Strategy is the art of bringing the greatest part of the forces of an army upon the important point of the theater of war or the zone of operations," 554. "Tactics is the art of using these masses at the points to which they shall have been conducted by well-arranged marches; that is to say, the art of making them act at the decisive moment and at the decisive point of the field of battle," 554. "Logistics is the practical art of moving armies, ... applying all possible military knowledge, and of ... primary significance to staff officers," 528-530.

¹⁴⁰ Frederick the Great, *The Instructions of Frederick the Great for His Generals, 1747*, In *Roots of Strategy, Volume 1*, trans. and ed. BG Thomas R. Phillips (Harrisburg: Stackpole Books, 1985), "The coup d'oeil of a general is the talent which great men have of conceiving in a moment all the advantages of the terrain and the use that they can make of it with their enemy," 341. Hittle, 402-406, 429-431. However, he held that inherent to the fundamental principle in war, massing forces at the decisive point, the key was in recognizing the time, location and forces required at the decisive point. Jomini emphasized that the knowledge of mass and maneuver as principles was not as important as the operational and tactical capacity to use those principles. Through prudent thought, bold action and acquired skill at a decisive point, a general could ensure victory as illustrated through Napoleon's early successes. "To detect at a glance the relative advantages presented by the different zones of operations, to concentrate the mass of the forces upon that one which gave the best promise of success, to be indefatigable in ascertaining the proximate position of the enemy, to fall like lightning upon his center if his front was too much extended or upon his flank by which he could more readily seize his communications, to out-flank him, to cut his lines, to pursue him to the last, to disperse and destroy his forces -- such was the system followed by Napoleon in his first campaigns," 469.

¹⁴¹ One may remember Frederick the Great for his bold leadership of Prussia, his pragmatic liberal visions, or his unexpected successes on the battlefield. Frederick saw the value of history and worked to teach his generals a thought process. Frederick considered Marquis de Feuquieres a "preceptor of generals." Feuquieres words, "tis the lively Eye of an able general which frequently decides a particular operation of war by the advantages he obtains from the enemy," may have influenced Frederick's definition of coup d'oeil. Jay Luvaas, "Frederick the Great: The Education of a Great Captain," In *The Evolution of Modern Warfare*, ed. LTC Scott Stephenson (Fort Leavenworth, Kansas: USACGSC, 1997), 72-79.

¹⁴² Clausewitz, 102.

¹⁴³ Hittle, 468. Jomini knew that arriving at the decisive point would be task in and of itself; there would be the fog and friction of war, the element of chance, and human nature. How a general dealt with the "fog and friction" of war was again *coup d'oeil*. The general, "Should endeavor in all his combinations, whether deliberately arranged or adopted on the spur of the moment, to form a sound conclusion as to the important point of the battlefield." The genius was in seizing the initiative by maintaining the principles of simplicity, surprise, and security. Through Jomini's words you hear a man who believed he possessed a military *coup d'oeil* of the highest order, displaying a condescending attitude towards those who achieved greater military rank, but of lesser perceived ability.

- ¹⁴⁴ van Creveld, 74-5.
- ¹⁴⁵ van Creveld, 255.
- ¹⁴⁶ Ibid., 259.
- ¹⁴⁷ Soloway, Adelson, and Ehrlich, 129-151
- ¹⁴⁸ MG Huba Wass de Czege and Major Jacob Biever, "Optimizing Future Battle Command Technologies," *Military Review*, 78(2), (March-April, 1998): 16.
- ¹⁴⁹ Stein, 420.
- ¹⁵⁰ Ernest T. Pascarella and Patrick T. Terenzini, *How College Affects Students: Findings and Insights from Twenty Years of Research* (Jossey Bass: San Francisco, CA, 1991), 62-113, 636-656.
- ¹⁵¹ Ibid., 62-113, 636-656.
- ¹⁵² Ibid., 114-161, 636-656.
- ¹⁵³ LTG Montgomery C. Meigs and COL Edward J. Fitzgerald, III, "University After Next," *Military Review*, 78(2), (March-April 1998): 39-45.
- ¹⁵⁴ Pascarella and Terenzini, 89, 91, 93. Anderson (1987) reported findings that indicated females performed better than males in problem analysis and algorithmic application when the problems were expressed verbally rather than mathematically. From his research on computer based instruction and problem solving he concluded that studies of "science decision making" imply that women are better than men at tasks defined as systems analysis rather than program coding. However, women's strength in analytical reasoning are a liability in developing the intuitive skills of an expert, such as chess grand master.
- ¹⁵⁵ van Creveld, 105-109.
- ¹⁵⁶ The idea for this sentence came from watching "Mr. Holland's Opus," a 1995 film directed by Steven Herek. In a scene near the end of the film, Olympia Dukakis tells Richard Dreyfus that the true purpose of education is to not only teach facts, but also develop a thought process that provides "a compass" for the students.
- ¹⁵⁷ John Adair, *Training for Decisions* (London: MacDonald and Company, 1971), 121-123.
- ¹⁵⁸ Adair, 90, 109, 125-140. Martin van Creveld, *The Training of Officers: From Military Professionalism to Irrelevance* (The Free Press, Macmillan, Inc. New York, 1990), 105-109. Frederic Brown, *The U.S. Army in Transition II: Landpower in the Information Age* (Washington, D.C.: Brassey's Incorporated, 1993), 117-118.
- ¹⁵⁹ Wass de Czege, 16.
- ¹⁶⁰ Ibid., 16.
- ¹⁶¹ Ibid., 114-161, 636-656.

¹⁶² SLA Marshall, in his book, *Sinai Victory* (Nashville: The Battery Press, 1985) detailed the Israeli shift in their training program to develop initiative on the battlefield and quick thinking in reserve officers. Within the context of the 100 hour 1956 Israeli-Egyptian Sinai War, Marshall explored many reasons for the Israeli success and Egyptian failure. Following the war, the Israelis developed an exercise that appeared very similar in theory to a BCPT or Warfighter, but executed in the field as a command post exercise (CPX). In the three day CPX, a battalion commander and staff are given a standard tactical exercise, such as capture a defended town, attack a hill, or seize a bridge. The first day of the exercise the commander has maps, aerial photographs, and time to conduct reconnaissance -- everything needed to make a decision in 22 hours of planning time. He has time to develop orders and gain information from subordinate commanders without any external requirements from higher headquarters. As soon as he delivers the order to the battalion, he gets a change in mission from his higher headquarters. The time of execution (H-hour) has changed and the brigade must now go to a new objective in an area other than what was originally planned, for example the hill on the right. He has maps and photos, but no time for reconnaissance and has 30 minutes before SP. The subordinate commanders begin to give status reports and right before he issues the order to move, a flash spot report comes in. The situation changes dramatically. The battalion lost half of its combat force. The enemy penetrated the defensive line on the left. The unit must now attack straight into a hill that is to its direct front. No time to check any staff reports or a map, the higher commander wants a decision now! These exercises clearly identified those commanders and staffs that were prepared and trained, 249-253.

¹⁶³ Department of the Army, Training and Doctrine Command, Center For Army Lessons Learned, *Division XXI Advanced Warfighting Experiment (DAWE), Initial Insights Report (IIR)*, Fort Leavenworth, Kansas, 21 January 1998, 52.

¹⁶⁴ John D. Rosenberger, "Training Battle Command: Coaching the Art of Battle Command," *Military Review*, 76(3), (May-June 1996): 26-38.

¹⁶⁵ Stein, 1393.

¹⁶⁶ Department of the Army, Training and Doctrine Command, Center For Army Lessons Learned, *Division XXI Advanced Warfighting Experiment (DAWE), Initial Insights Report (IIR)*, Fort Leavenworth, Kansas, 21 January 1998, 47.

Annex A Glossary

- Accommodation:** In the cognitive thought process if a concept or object does not fit into our existing cognitive structure, we make changes to our thought structure.
- Army Battle Command System:** migration of all fielded and developmental Army C2 systems into one fully integrated and interoperable system with seamless connectivity from the NCA to the foxhole.
- Assimilation:** In the cognitive thought process it means the taking in, digesting; in the intellectual sphere we have a need to assimilate objects or information into our cognitive structures.
- Awareness:** To be aware of something implies knowing something either by perception (conscious) or by means of information (cognizant).
- Battle Command:** the art of decision making, leading, and motivating soldiers and their organizations into action to accomplish missions: includes visualizing current state and future state, then formulating concepts of operations to get from one to another at least cost; also includes assigning missions, prioritizing and allocating resources, selecting the critical time and place to act, and knowing how and when to make adjustments during the fight.
- Battle Dynamics:** five major interrelated dynamics that define significant areas of change from current operations to Force XXI Operations; dynamics are battle command, battlespace, depth and simultaneous attack, early entry, and combat service support.
- Battlespace:** components of this space are determined by the maximum capabilities of friendly and enemy forces to acquire and dominate each other by fires and maneuver and in the electromagnetic spectrum.
- Broadcast Intelligence:** capability to rapidly "pull down" or broadcast accurate/real-time intelligence (all levels, even national level) to the lowest possible tactical level, precluding the layered procedural intelligence flow of information.
- Cognitive psychology** applies to the study of thinking, concept formation, and problem solving. Work in this field has been much influenced and aided by the use of computers. Computers are used to present problems and tasks to subjects and to model the thinking and problem-solving processes. The impact of computers on cognitive psychology is also evident in the theories used to describe human thought.
- Command and Control Warfare:** the integrated use of operations security, military deception, psychological operations, electronic warfare, and physical destruction mutually supported by intelligence to deny information to, to influence, or to degrade adversary C2 capabilities while protecting friendly C2 capabilities against such actions; C2W applies across the full range of military operations and all levels of war.
- Common Sense:** Believed to have been first used by Rene Descartes, "*le siege du sens commun*." Common sense are practical attitudes and widely accepted beliefs which may be hard to justify, but which are generally assumed to be reliable.
- Complexity:** Detail complexity contains many variables in a static environment. Dynamic complexity has subtle cause and effect relationships where the affect of interventions over time is not obvious. Senge indicated that the real leverage in most management situations lies in understanding dynamic complexity, not detail complexity.

Coup D'oeil: Baron Antoine Jomini's *Art of War* discussed the importance of tactics, terrain, logistics, combined arms, courage, policy, and strategy. Jomini's contribution however is not that the general should have a systematic technical knowledge, but rather the ability to **know when to do what first**. That recognized ability and insight of the great captains, *coup d'oeil* as Frederick wrote, was of the tactical thought process, not an application of approved solutions. Clausewitz expanded the concept of *coup d'oeil* as the genius to deal with the uncertainties of war and the strategic inward eye. Although we have become a system of systems, the most important system remains the human brain. Technology may liberate leaders to make decisions, but it may also debilitate the decision making process.

Deductive and inductive reasoning: Deductive and inductive refer to two distinct logical processes. Deductive reasoning is a logical process in which a conclusion drawn from a set of premises contains no more information than the premises taken collectively. The truth of the conclusion is dependent only on the method and is logically true even if the premise is absurd. Inductive reasoning is a logical process in which a conclusion is proposed that contains more information than the observation or experience on which it is based. The truth of the conclusion is verifiable only in terms of future experience and certainty is attainable only if all possible instances have been examined.

Depth and Simultaneous Attack: the simultaneous application of combat power against an enemy throughout the depth and breadth of the battlefield; objective goes beyond defeating the enemy; objective is to accelerate enemy defeat

Development: Understanding that no one perspective is capable of explaining or defining everything, I will integrate a number of theories and definitions. Development is a hierarchical process, in which each step is seen as a confrontational challenge to a person's previous state that requires extension (differentiation and integration) and redefinition (assimilation and accommodation) of individual attitudes or competencies in the midst of increasing uncertainty and complexity to again achieve a balance (equilibration and the orthogenic principle). I acknowledge the limitations of any approach, including my own, that could not account for everything.

Dialectical Theory: Any theory that holds that change occurs when our ideas meet with counter-evidence that motivates us to formulate new and better ideas.

Differentiation: Occurs when a global whole separates into parts with different forms or functions.

Distributed Operations: Employing our emerging capabilities, operations and functions are executed throughout the depth, width and height of our battlespace. These operations are distributed, that is executed where and when required to achieve decisive effects vice concentrated at a possibly decisive point. Key to distributed operations is the empowerment of soldiers and leaders to use their initiative, willpower, and professional expertise to carry out critical tasks at all echelons. Distribution enables Army elements to take advantage of internettted communications avoiding the tendency to use the chain of command as the chain of information. Dispersion empowers subordinates to operate independently within the commander's intent, leading to synergistic effects that exceed synchronization by a centralized headquarters. Distributed operations lead to agility, with greater flexibility to react to multiple changes in the situation. There are certain functions that are best executed centrally, primarily management of resources. Force XXI Operations seek to execute each function using the best operational scheme. Through experimentation and operational experience, it appears the best approach is: develop a central intent and concept; conduct parallel planning and coordination enabled by digitization; and execute distributed operations to achieve the objective.

Electronic Warfare: military actions that include: electronic attack-the use of either electromagnetic or directed energy to degrade, neutralize, or destroy an enemy's combat capability; electronic

protection-those actions taken to protect personnel, facilities, and equipment from friendly or enemy employment of electronic warfare; electronic warfare support-those actions tasked by an operational commander to search for, intercept, identify, and locate sources of radiated electromagnetic energy for the purpose of immediate threat recognition.

Empty Battlefield: describes the perception that a soldier is virtually alone on the battlefield; describes the changed appearance of the battlefield when soldiers begin dispersing and seeking cover in response to increasing lethality of weapon systems.

Equilibration: Is the conflict resolution between experiences that contradict the original thought structure and thus promote cognitive development (Piaget).

Five Stages of Skill Acquisition; a development hierarchy

| Skill Level | Components | Perspective | Decision | Commitment |
|----------------------|------------------------------|-------------|------------|---|
| 1. Novice | Context-free | None | Analytical | Detached |
| 2. Advanced Beginner | Context-free and situational | None | Analytical | Detached |
| 3. Competent | Context-free and situational | Chosen | Analytical | Detached understanding and deciding. Involved in outcome. |
| 4. Proficient | Context-free and situational | Experienced | Analytical | Involved understanding. Detached deciding. |
| 5. Expert | Context-free and situational | Experienced | Intuitive | Involved |

Novice: The novice learns to recognize various objective facts and features relevant to the skill and acquires rules for determining actions based upon those facts and features. Elements of the situation to be treated as relevant are so clearly and objectively defined for the novice that they can be recognized without reference to the overall situation in which they occur (context free). Lacking the sense for the overall task, a novice depends upon learned rules to act. After the acquisition and application of more than just a few rules, the exercise of the skill requires so much concentration that the novice's capacity to talk or listen to advice is extremely limited.

Advanced Beginner: After the novice has considerable experience in coping with real situations, performance improves to an acceptable level. While that encourages the learner to consider more context-free facts and to use more sophisticated rules, it also teaches him a more important lesson involving an enlarged conception of the world of skill. Through the perceived similarity with prior examples, the advanced beginner starts to recognize meaningful elements when they are present. Experience seems immeasurably more important than any form of verbal description.

Competent: With more experience, the number of recognizable context-free and situational elements present in a real-world circumstance eventually become overwhelming. A sense of what is important is missing. To cope with the problem, people learn, or are taught, to adopt a hierarchical procedure of decision-making. First by choosing a plan to organize the situation, and then by examining only a small set of factors that are most important given the chosen plan, a person can both simplify and enhance his performance. The difference here is the competent performer chooses an organization plan, feels a responsibility for the choice and the results, and is involved in what occurs thereafter. These are internalized lessons, not easily forgotten.

Proficient: The two highest levels of skill, are characterized by a rapid, fluid, involved kind of behavior that bears no apparent similarity to the slow, detached reasoning of the problem-solving process. The proficient performer is deeply involved in the task and will be experiencing it from some specific perspective because of recent events. He has the ability to intuitively respond to patterns without decomposing them into component feature, a sense of "holistic discrimination and association." Intuition or

know-how is neither wild guessing nor supernatural inspiration, but the sort of ability we all use all the time as we go about our everyday tasks. The proficient performer, while intuitively organizing and understanding his task, will still find himself thinking analytically about what to do. Elements that present themselves as important, thanks to the performers experience, will be assessed and combined by rule to produced decisions about how to best manipulate the environment.

Expert: An expert generally knows what to do based on mature and practiced understanding. When deeply involved in coping with his environment, he does not see problems in some detached way and work at solving them, nor does he worry about the future and devise plans. An expert's skill "has become so much a part of him that he need be no more aware of it than he is his own body." After enough experience within a specific domain, memory is modified, codified and organized in such a manner that there is no need to decompose the patterns, but seen in an instant as the holistic picture. Experts performance may be seen as ongoing and non-reflective, but given time and when the outcomes are crucial, an expert will deliberate before acting. The deliberation may not require analytic problem solving, but rather critically reflecting on one's intuitions. An ability to discriminate an immense number of situations is produced by experience. "With enough experience in a variety of situations, all seen from the same perspective or with the same goal in mind but requiring different tactical decisions, the mind of the proficient performer seems to group together situations sharing not only the same goal or perspective but also the same decision, action, or tactic." At this point not only is a situation, when seen as similar to a prior one, understood, but the associated decision, action, or tactic simultaneously comes to mind.

Force Projection: the movement of military forces from CONUS or a theater in response to requirements of war or operations other than war; force-projection operations extend from mobilization and deployment of forces, to redeployment to CONUS or home theater, to subsequent demobilization

Freud, Sigmund (1856-1939). The noted Viennese physician Sigmund Freud was one of the first to suggest workable cures for mental disorders. Although Freud's theories were at first disputed, his work became the foundation for treating psychiatric disorders by psychoanalysis. In more recent times his theories have once again been challenged.

Full-Dimensional Operations: the application of all capabilities available to an Army commander to accomplish his mission decisively and at the least cost across the full range of possible operations

Gestalt psychology provides a healthy balance to the overly atomistic psychologies both in Europe and the United States. A group of psychologists--including Wilhelm Wundt, Kurt Koffka, Wolfgang Kohler, and Max Wertheimer--contended that the atomistic approach could never lead to the understanding of major psychological phenomena. A symphony, they argued, is more than the sum of its individual notes. The form (Gestalt) of anything has qualities that are different from, and that cannot be attributed to, the sum of its parts. To support their argument, the Gestalt psychologists focused on perception. They demonstrated that perception is organized into holistic rather than atomistic components. Perception is organized into the figure, such as a soloist playing a concerto, and the ground, the orchestral accompaniment. Visually too the perception of the observer is centered on the soloist and the conductor, who are the figures, and the orchestra, which is the ground.

Hegel, Georg Wilhelm Friedrich (1770-1831). One of the most influential of the 19th-century German philosophers, Georg Wilhelm Friedrich Hegel also wrote on psychology, law, history, art, and religion. Karl Marx based his philosophy of history on Hegel's law of thought, called the dialectic. In this dialectic an idea, or thesis, contains within itself an opposing idea, called antithesis. Out of the inevitable conflict between these opposing concepts is born a third, totally new thought, the synthesis. Applied to history by the Marxists, Hegel's concepts were used to formulate the notion of the class struggle. From the strife over the ownership of the means of production would arise a new classless society--the synthesis. The significance of Hegel's ideas stems in part from the fact that they can be applied not only to abstract thought but also to psychology, religion, and history. An essential element of his system was his belief that reality can only be grasped when examined

as a whole and that any attempt to discover truth by scrutinizing a single facet of reality is doomed to failure.

Information: The communication of knowledge derived from study, experience, or instruction of a specific event or situation.

Information Age: the future time period when social, cultural, and economic patterns will reflect the decentralized, nonhierarchical flow of information; contrast this to the more centralized, hierarchical social, cultural, and economic patterns that reflect the Industrial Age's mechanization of production systems.

Information Operations: continuous combined arms operations that enable, enhance, and protect the commander's decision cycle and execution while influencing an opponent's; operations are accomplished through effective intelligence, command and control, and command and control warfare operations, supported by all available friendly information systems; battle command information operations are conducted across the full range of military operations.

Information Warfare: actions taken to preserve the integrity of one's own information system from exploitation, to corrupt or destroy an adversary's information system, and, in the process, to achieve an information advantage in the application of force.

Integration: (Cognitive Psychology) Coordinating and organizing thoughts into a whole

Integration: Force XXI Operations are fully integrated with Joint, Multi-national, and Non-governmental partners. Recent experience has reminded us that Army operations have never been and will never be independent. From initial receipt of mission, through deployment, operations, and transition to follow-on operations Army elements function as an integral part of a Joint Task Force. That Joint Task Force is linked to Coalition partners and usually operates in conjunction with one or more non-governmental agencies such as the International Red Cross, United Nations, etc. Integrated operations enable the Army to leverage the full suite of capabilities the services bring to the battlespace. Army helicopters operating from Navy aircraft carriers during Operation RESTORE DEMOCRACY and TMD warnings from SPACECOM are two examples of fully integrated operations.

Intent: The state of a person's mind that directs his actions toward a specific object; meaning or significance.

Judgment: The mental ability to perceive and distinguish relationships or alternatives and exercise common sense or wisdom: arbitration and adjudication.

Kant, Immanuel (1724-1804). The philosopher of the 1700s who ranks with Aristotle and Plato of ancient times is Immanuel Kant. Kant's most famous work was the "Critique of Pure Reason" (published in German in 1781). In it he tried to set up the difference between things of the outside world and actions of the mind. He said that things that exist in the world are real, but the human mind is needed to give them order and form and to see the relationships between them. Only the mind can surround them with space and time. The principles of mathematics are part of the space-time thoughts supplied by the mind to real things. Kant said that thoughts must be based on real things. Pure reason without reference to the outside world is impossible. We know only what we first gather up with our senses. Yet living in the real world does not mean that ideals should be abandoned. He argued for a stern morality. His basic idea was in the form of a Categorical Imperative. This meant that humans should act so well that their conduct could give rise to a universal law.

Knowledge: A familiarity, awareness, or understanding gained through experience or study; the sum or range of what has been perceived, discovered, or inferred. Knowledge consists of a collection of beliefs with varying strengths of certainty and affective quality.

Military Decision Making Process: A single, established, and proven analytical process. The MDMP is an adaptation of the Army's analytical approach to problem solving. It is time consuming, but focuses on detailed integration, synchronization, and coordination.

Multi-Dimensional: Force XXI will operate in an expanded battlespace. This battlespace goes beyond the traditional physical dimensions of width, depth and height. It includes portions of the electro-magnetic spectrum. This extends beyond the physical boundaries of the division through its communications and digital connectivity to other Army, Joint and Coalition elements, even reaching back to CONUS from the Theater of Operations. Battlespace will also be defined by the human dimension; this includes not only soldiers and leaders, but also the civilian population in which operations are being conducted, citizens and families in the United States, and the peoples of the world. Finally, time is a dimension of battlespace that must be mastered. This concept seeks to seize and exploit the initiative to set the tempo of a battle, not just acting faster than the enemy, but acting at that speed which is best for execution of the friendly plan. Battlespace will generally be framed by METT-T and largely shaped by corps or JTF operations. This shaping includes not only the application of fires and combat power, but also deception, PSYOPS, civil affairs, host nation support, sustainment, intelligence, and reinforcement of existing terrain and infrastructure.

Non-Linear: Force XXI Operations are characterized by non-linearity, executing tasks across the entire battlespace rather than massing combat power at the Forward Line of Troops (FLOT). Non-linear operations do not seek a rigid organization of the battlespace into close, deep, and rear operations. Instead, the battlespace is fluid, changing as METT-T changes through the duration of mission preparation and execution. Peacetime engagement, humanitarian assistance, and peacekeeping missions are generally executed non-linearly, conforming to the physical characteristics or infrastructure of the area of operations or based on mission requirements. Non-linearity requires soldiers and leaders to possess greater situational awareness, allowing risk to be accepted with space between units rather than more traditional contiguous operations. Non-linearity also increases the requirement of each divisional element, maneuver, CS and CSS for all-around security.

Orthogenic principle: Whenever development occurs, it proceeds from a state of relative lack of differentiation to a state of increasing differentiation and hierarchic integration (Heinz Werner's view of development). Werner's comparative theory focused on the notion of *Gestalt*, in that we tend to close or complete figures into whole patterns.

Piaget, Jean (1896-1980). The Swiss psychologist Jean Piaget was the first scientist to make systematic studies of how children learn. He was also a 20th-century pioneer in developmental psychology. Piaget viewed children as people who continually make and remake their own reality. They grow mentally by taking the simple concepts they learn early on and integrating them into more advanced ones. They try to master their reflexes, and they constantly experiment.

Precise: Force XXI Operations are characterized by synchronized attacks throughout the battlespace on units and targets which have been subjected earlier, condition setting attacks, to enhance their vulnerability. Such decisive operations require great precision. Precision in decisive operations is enabled by three emerging capabilities. First digitization, providing soldiers and leaders at each echelon the information required for making informed decisions. Second, a full suite of strategic, operational, and tactical sensors, linked to analytical teams will fuse combat information into situational awareness across the battlespace with greater clarity than ever before. Lastly, simulations enable Army elements to be tailored based on emerging situation/crisis, plan operations based on METT-T, wargame and rehearse those operations yielding precision in

execution. Precision in operations goes beyond precision strike; it includes every aspect of military operations from deployment through combat and redeployment or transition to other operations. In force projection this means the right force, effectively trained and rehearsed, to the right place on time. In combat operations, precision means precise maneuver, positioning elements correctly in time and space, complemented by precision systems and precision munitions and setting conditions which minimize the enemies' ability to rapidly respond and desynchronize our capabilities. Precision in force protection includes employing dynamic obstacles synchronized in time and space which create either protective or shaping effects; additionally air/missile defenses must be effectively employed to counter each enemy capability based on intelligence at each echelon. Precision in sustainment includes proactive arming, fueling, fixing, and manning empowered by common situational awareness of requirements and asset availability.

Relevant Common Picture: Is a digital, near-real time representation of the location of friendly and enemy units. The enhanced communications abilities and technologies allow the creation of a common operational picture, which is the near simultaneous sharing of the operational picture. This common data operational picture means something to everyone who looks at it. The set of human perceptions extrapolated from the operational picture results in situational awareness.

Satisfice: Concept based on a 1946 article by Herbert A. Simon, "The Proverbs of Administration." Satisficing is selecting the most optimal solution available and accepting the limitation that the best solution may be unattainable.

Simultaneity: The concept of decentralized operations that is multi-dimensional, precise, distributed, and non-linear yields the capability to conduct simultaneous operations across the battlespace. Simultaneous operations seize the initiative and present the enemy leadership with multiple crisis, but no effective response. Digitization creates the ability to plan, coordinate, and execute actions simultaneously. Each of these actions creates an effect, the sum of which is greater than if they were discrete and sequential. Rather than a single concentrated attack, we execute a series of attacks (lethal and non-lethal) as near-simultaneously as possible. For distributed operations to have decisive effect upon the adversary, they must be conducted at a tempo and sequence that he cannot endure. The principle of simultaneity of action is paramount to the success of Decisive Operations. Commanders determine critical objectives and sequence of actions to overwhelm the adversary's combat and support structures in a near-simultaneous manner to cause rapid defeat or collapse. Upon indication of collapse, highly mobile forces exploit by fires and maneuver to gain control and dominate the contested battlespace.

Situational Awareness: The ability to have accurate and real-time information of friendly, enemy, neutral, and noncombatant locations; a common, relevant picture of the battlefield scaled to specific level of interest and special needs.

Social psychology looks into all facets of human social interaction. Among the problems studied by social psychologists are such matters as the development of friendship, the nature of romantic attachment, and the relative effectiveness of cooperation and competition on achievement. In recent years social psychology has included the study of attribution. Attribution theory recognizes that psychological perceptions of events do not always correspond to objective realities.

Understanding: To understand means to perceive and comprehend the nature and significance thoroughly by close contact with or long experience of.

Annex B Decision Making Models and Command and Control Paradigms

Figure 1. Boyd's Observe, Orient, Decide, Act Loop

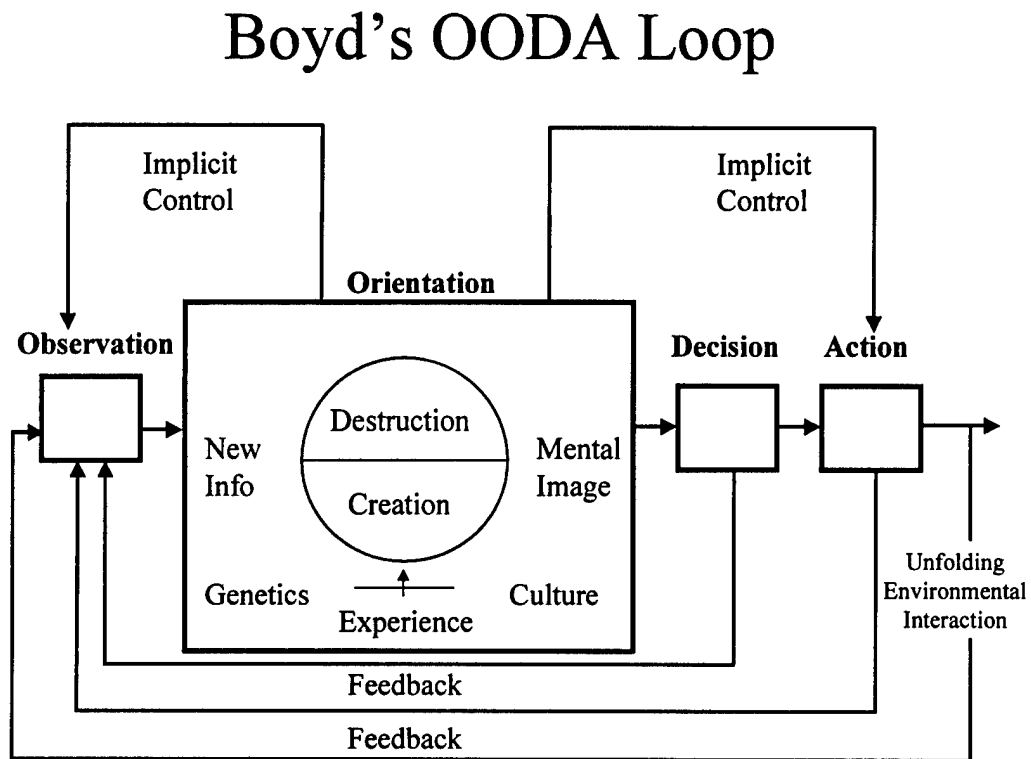


Figure 2. The Appraise, Survey, Weigh and Deliberate Model

The ASWD Paradigm

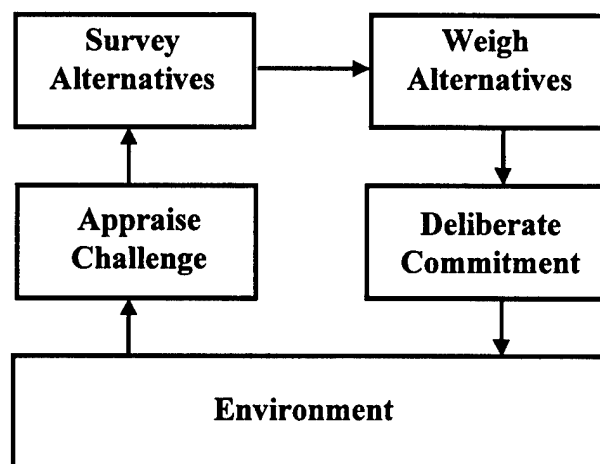


Figure 3. The Stimulus, Hypothesis, Option, Response Paradigm

The SHOR Paradigm

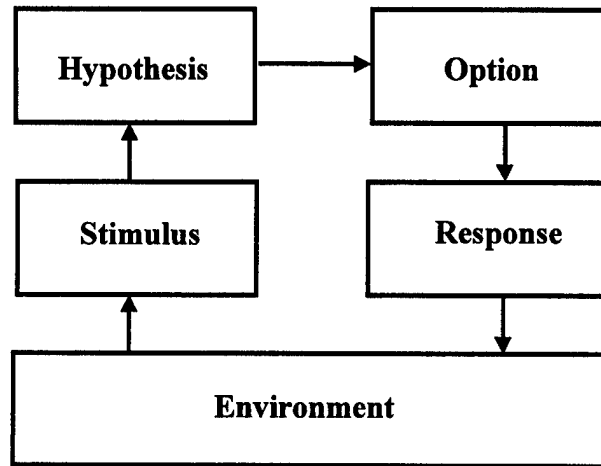


Figure 4. The Situation, Information, Command, Response Paradigm

The SICR Paradigm

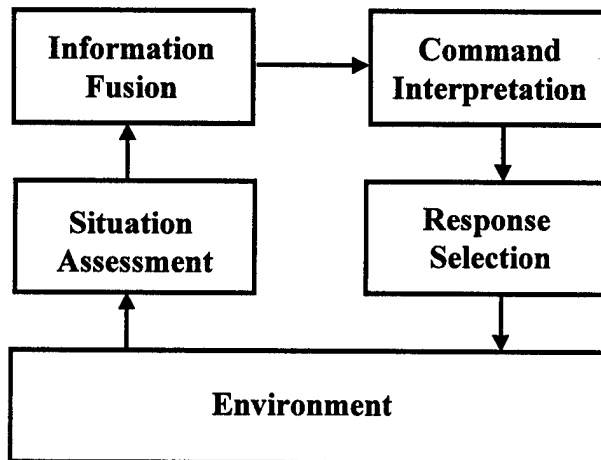


Figure 5. Process, Analyze, Decide, Implement

The PADI Paradigm

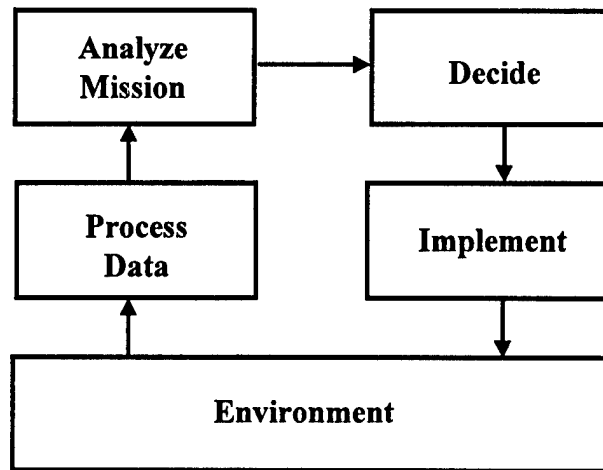


Figure 6. Enter, Occupy and Leave Paradigm

The EOL Paradigm

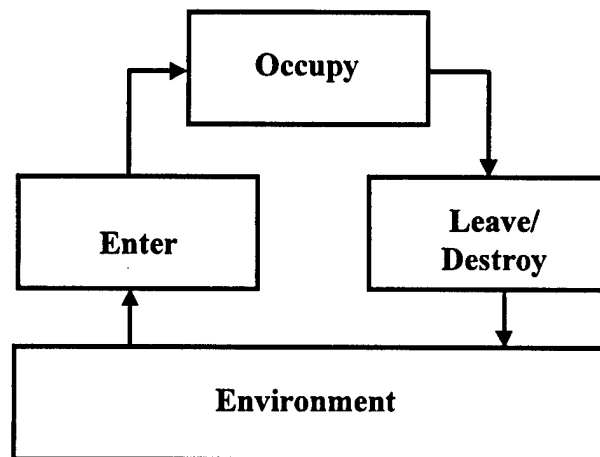


Figure 7. The See, Fuse, Maneuver, and Assess Model

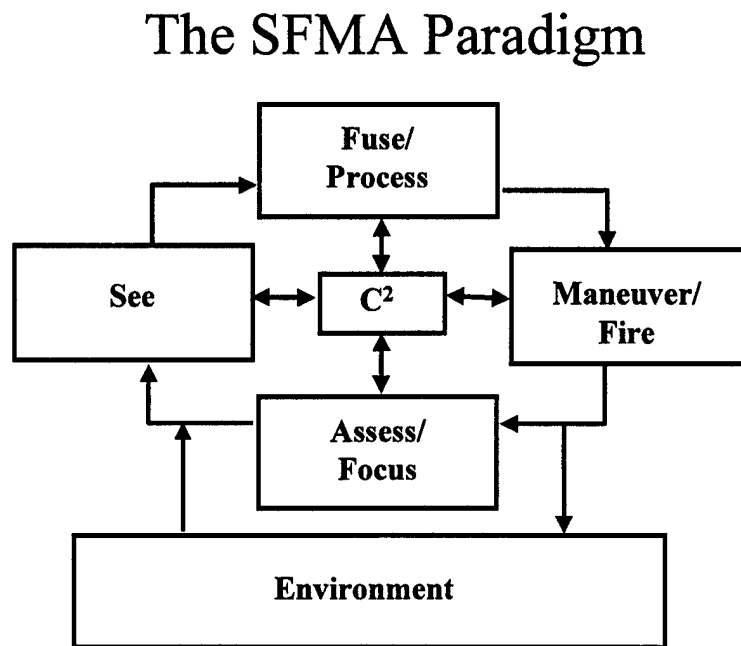


Figure 8. Sense, Process, Compare, Decide, Act Paradigm

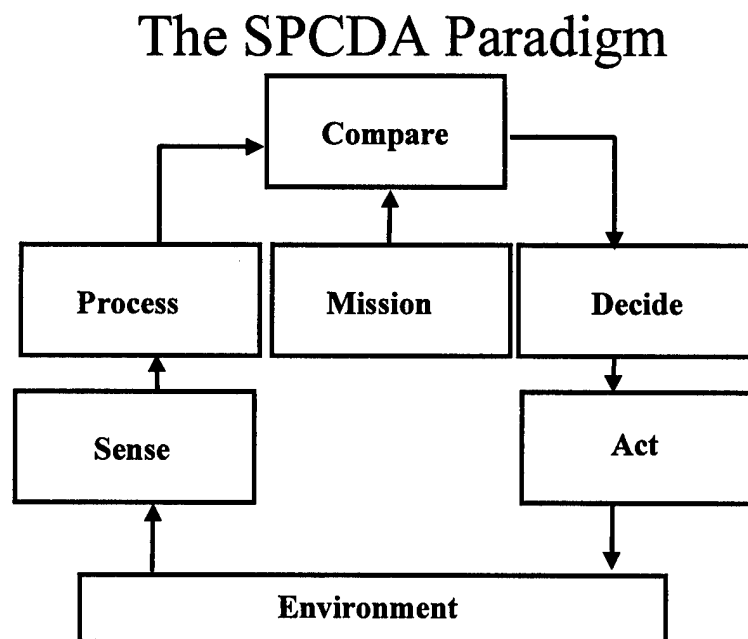


Figure 9. Monitor, Understand, Alternatives, Predict, Decide, Direct Model

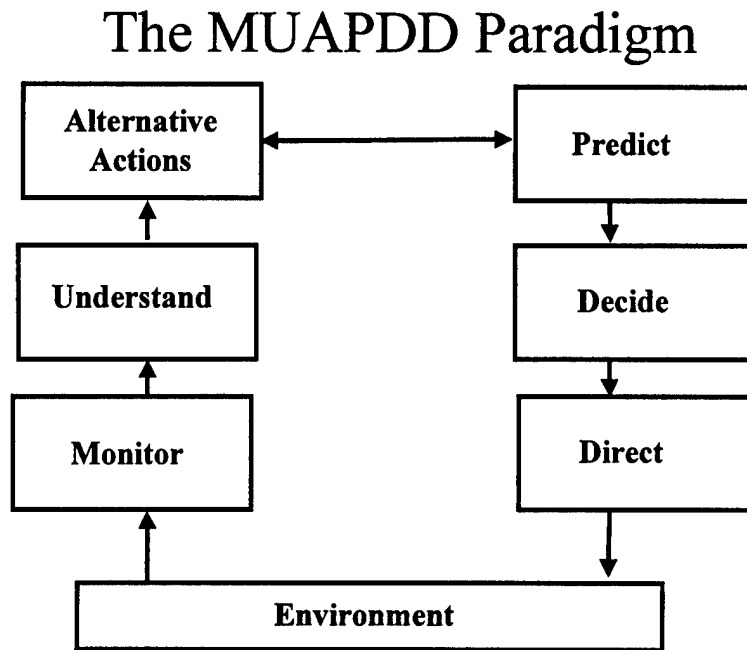


Figure 10. The IdCCCo Paradigm

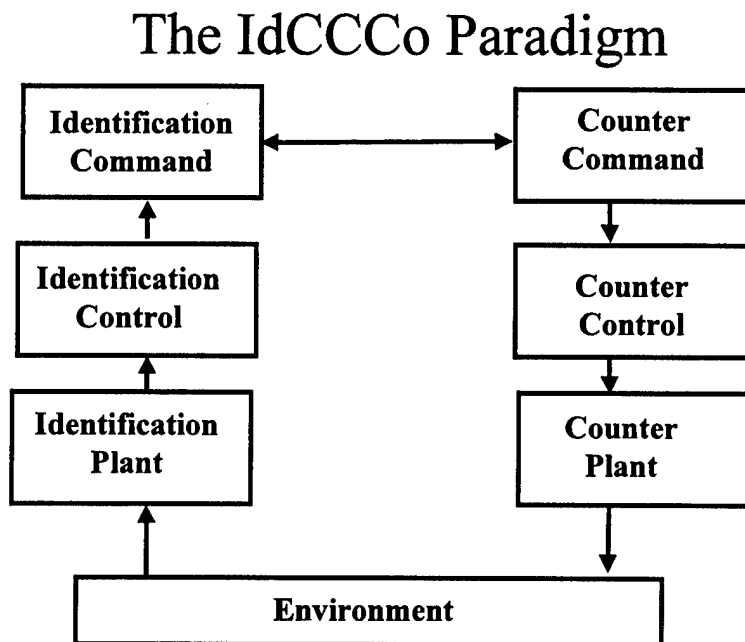


Figure 11. The PCMCP Paradigm.

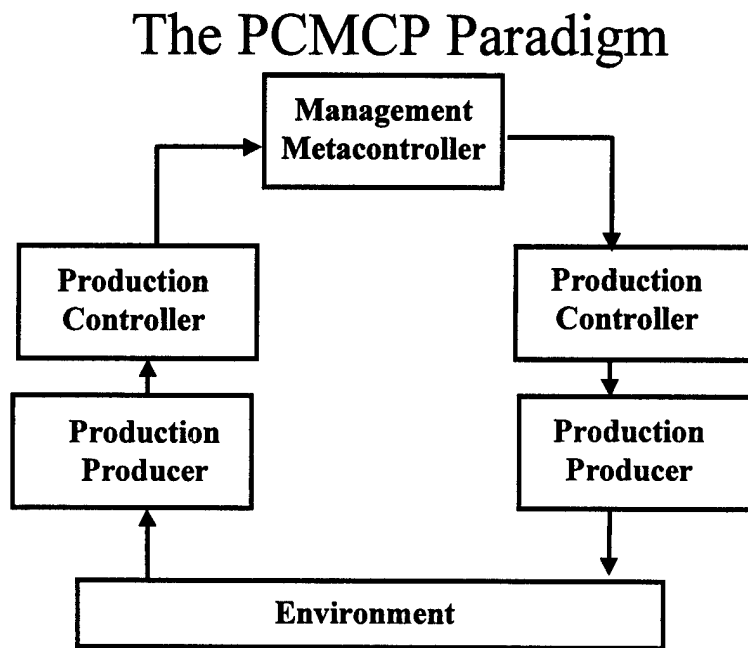


Figure 12. The CHCCD Paradigm.

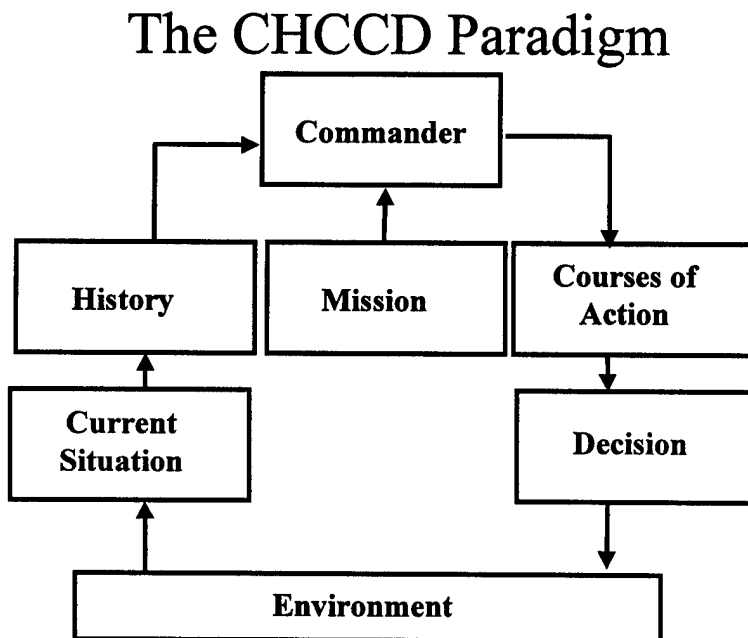


Figure 13. Concept, planning and/or preparation, execution, and assessment methodology

The CPEA Methodology

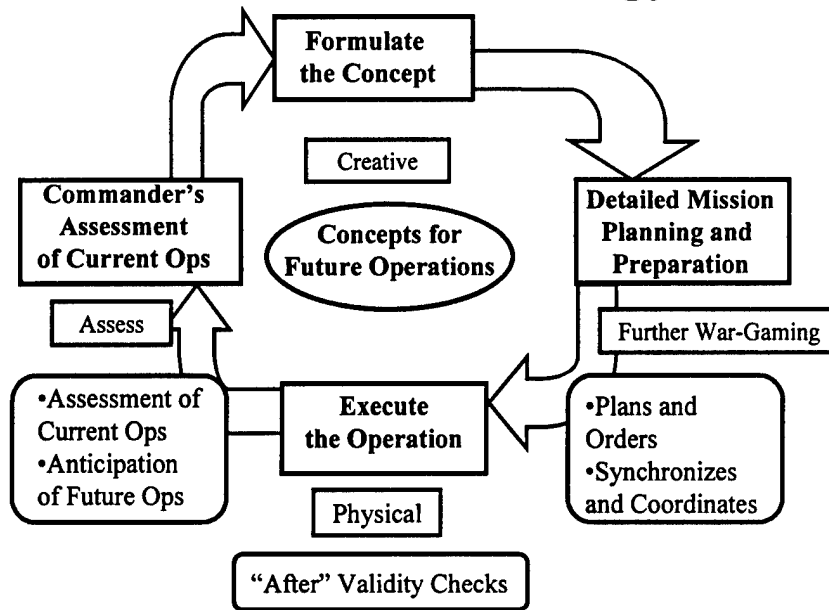
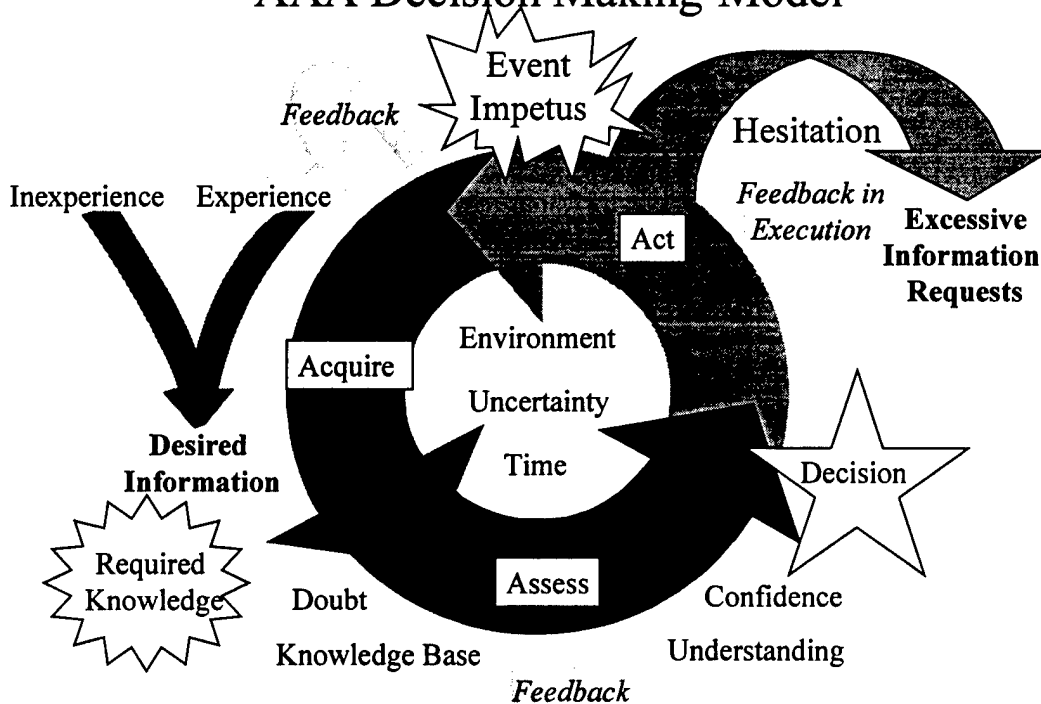


Figure 14. Dymek's "Triple A" Model

AAA Decision Making-Model



Annex C Decision Making Experimental Research Data and Summaries

The Nature of Expertise. eds. Michelene T.H. Chi, Robert Glaser, and Marshall Farr

(xvii) 1. *Experts excel mainly in their own domains.* A very intelligent person might be that way because of specific local features of his knowledge-organizing knowledge rather than because of global qualities of "thinking."

(xvii) 2. *Experts perceive large meaningful patterns in their domain.* This ability to see meaningful patterns does not reflect a generally superior perceptual ability; rather, it reflects an organization of the knowledge base.

(xviii) 3. *Experts are fast; they are faster than novices at performing the skills of their domain are, and they quickly solve problems with little error.* Although studies in the literature actually find experts slower at novices in the initial phases of problem solving, experts solve problems faster overall. Possible explanation for experts' speed in solving problems rests on the idea emphasized earlier that experts can often arrive at a solution without conducting extensive search.

(xviii) 4. *Experts have superior short-term and long-term memory.* Not because their memory is larger, but because the automaticity of many portions of their skills frees up resources for greater storage.

(xviii-xix) 5. *Experts see and represent a problem in their domain at a deeper (more principled) level than novices; novices tend to represent a problem at a superficial level.* Experts used the principles of mechanics to organize categories, whereas novices built their problem categories around literal objects stated in the problem description.

(xix) 6. *Experts spend a great deal of time analyzing a problem qualitatively.* Experts typically try to "understand" a problem, whereas novices plunge immediately into attempting to apply equations and solve for an unknown.

(xx) 7. *Experts have strong monitoring skills.* Experts seem to be more aware than novices of when they make errors, why they fail to comprehend, and when they need to check their solutions.

Team Information Processing: A Normative-Descriptive Approach

Linda G. Bushnell, Daniel Serfaty and David L. Kleinman

Based on the distributed decision making dynamic, they develop a normative construct to support sequential information processing behavior based on optimal estimation theory. Distributed decision making is the intellectual theory behind decentralized operations and initiative oriented warfighting. The important focus of this research was the collective nature of a decision making team. The descriptive factors – recency, anchoring to prior knowledge, systematic underwriting of a partner's expertise, and non-discounting of common prior information – were identified and integrated into their normative model. The most important finding from the research was a polarization of perception towards a partner's expertise and the order in which information was presented.

Experimental Investigation of the Bounded Rationality Constraint

Anne-Claire Louvet, Jeff T. Casey and Alexander H. Levis

Abstract: The cognitive limitation of human decision makers is one of the determinants of organizational performance. A basic assumption in the analytical methodology for organizational design is that the bounded rationality sets an upper limit on the amount of information that can be processed. The results of this experiment indicate that a threshold level can be established and used in the design of multi-person experiments.

The important finding of this research is that the cognitive work load and tempo of operations can be specified so that the individual members operate below, but near, their threshold. Although every person reaches a task work load at which they can no longer make effective decisions, the data suggests a normally distributed relationship. Therefore each individual can be calibrated to the amount of information they can receive and still make quality decisions.

Information Processing Theory: Some Concepts and Methods Applied to Decision Research

John W. Payne

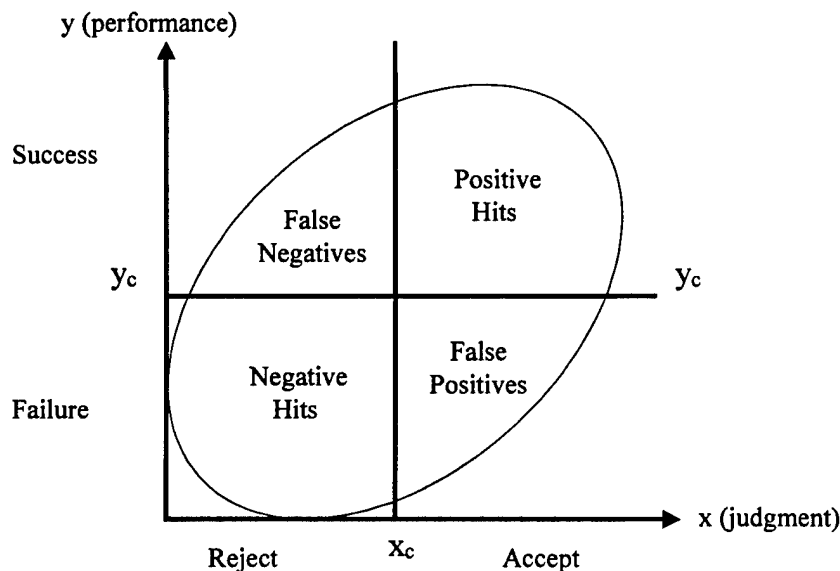
This study of explicit risk choices and gambling in decision making focused not on the traditional outcomes measurements in terms of money, but rather in the coding and editing processes of choices. The best known process tracing technique is in the collection of verbal reports, thinking aloud while performing a task. Although this introspective method was mainly abandoned in the face of criticism from behavioral scientists, it is still an effective and cost effective means of gaining insight into the decision making process. To develop programs that assess process tracing we could focus on the interpretations of written instructions compared to oral or visual. Decision makers could be presented with relatively complex problems in the form of written decision cases and forced to articulate their thought process just as we do in solving ethical dilemmas or business school case studies. The use of historical vignettes to illustrate salient tactical or strategic examples in professional development programs is an example of this methodology. The difference is to have a calibrated observer to record the thought patterns and linkages made by the decision maker and not focus merely on the outcomes.

Learning from Experience and Suboptimal Rules in Decision Making.

Hillel J. Einhorn

The basic theme of this research is that outcome information, without knowledge or task structure, can be irrelevant for providing self-correcting feedback about poor heuristics. Furthermore, knowledge of task structure may be difficult to achieve because of the inductive way we learn from experience. Just because an individual does not develop the optimal decision making rules, does not mean that person will not arrive at an effective, workable solution. We all will make mistakes or sub-optimal judgments, the important lesson is in how we learn from them.

Action-outcome combinations that result from using judgment to make an accept/reject decision



"Cognitive Psychology, Information Technology, and Education."

A study from the Netherlands (Beishuizen and de-Leeuw, 1987) on cognitive psychology, information technology, and education discusses the potential value of the computer as a research instrument with which complex hypotheses on the learning of cognitive skills can be formulated clearly, accurate data can be obtained, and testing of hypotheses can be facilitated. The results of computer-assisted research on complex and long-term cognitive learning processes, intellectual capacity, and cognitive control are considered. First, educational methods can be adapted successfully to individual differences between students. Second, learning environments can be enriched with tools for independent learning. However, higher order cognitive skills necessary to solve complex problems are only achieved when the students begin with an understanding of the problem and use the computer as an instrument. Computers did not significantly enhance the ability to solve ill-defined problems.

"The Third Revolution in Computers and Education"

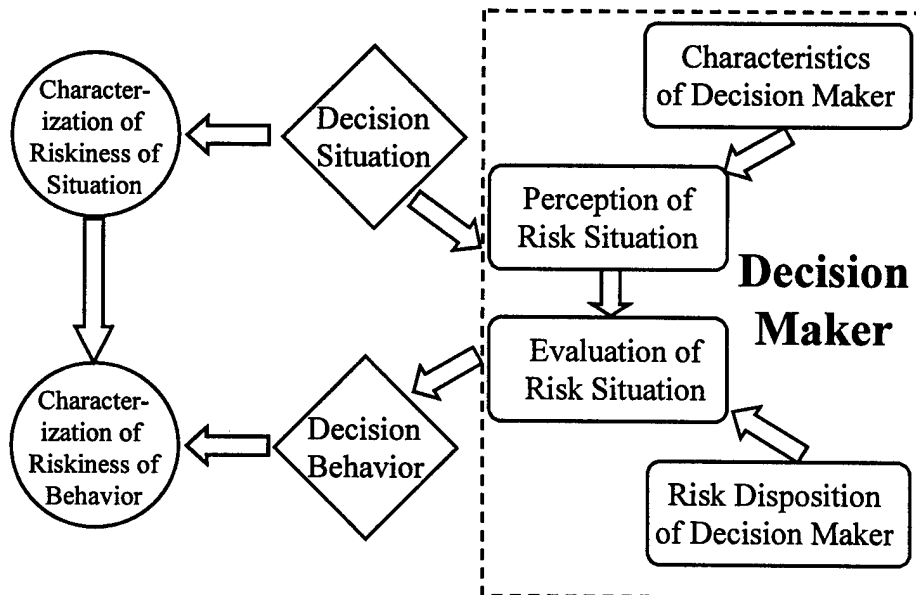
Andrea diSessa contends that there is an opportunity to build a legitimate scientific and engineering base for science education. DiSessa states that computers play a central role in this opportunity, but in order to realize these hopes, focus must be on fundamental issues of how people learn and what and how teachers should teach. Computers can be employed to inspire the use of mental models and innovative educational techniques.

Real Money Lotteries: A Study of Ideal Risk, Context Effects, and Simple Processes

Kenneth R. MacCrimmon, William T. Stanbury, Donald A. Wehrung

Baseline assumption is that all decisions involve risk taking in choosing alternatives. Especially critical for the study of military decision making where uncertainty is expected and the risk is often high. Their first finding was that risk may be operationalized in conflicting ways – variance, range, and mean. What they then turned to was developing a model to predict ideal risk, or the line at which major gains and losses remained in question. The significance of this study was in situations of multiple, random factors, regardless of the payoff, decision makers were three times less likely to assume risk in the decision. Therefore, the decision maker's hesitancy was based more on the lack of certainty than in the possible outcomes. Below is the model they presented to study risk taking in decision making.

Paradigm for studying risk taking



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